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The Concept of Operations for a U.S. Army Combat-Oriented Logistics Execution System with VISION (Visibility of Support Options)

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PREFACE

This report describes the concept of operations for a U.S. Army combat-oriented Logistics Execution System with VISION (Visibility of Support Options). It is the first in a series that describes concepts for logistics decision support systems designed to improve the wartime and peacetime availability of important U.S. Army weapon systems through improved management of logistics resources.

The VISION series of decision support systems recognizes that inherent uncertainties will cause imbalances between requirements for logistics resources and their availabilities in both peacetime and wartime environments. As a consequence, the VISION series provides methods that logisticians can use to adjust their actions to compensate for such uncertainties. *This first* VISION *report develops concepts* for dealing with uncertainties in the design of execution activities. Subsequent reports will develop concepts for dealing with uncertainties in the design of information systems that have to do with logistics planning, programming, budget allocation, and command and control processes. The reports should provide meaningful ideas and direction for the development of an Army strategic plan for logistics systems modernization.

The research is part of the Readiness and Sustainability Program of RAND's Arroyo Center. This research project, entitled "Logistics Management System Concepts To Improve Weapon Systems Combat Capability," is jointly sponsored by the Assistant Deputy for Materiel Readiness, Army Materiel Command (AMC) and the Commanding General of the Training and Doctrine Command's (TRADOC's) Logistics Center. The report should be of interest within AMC, Army Headquarters, and TRADOC's Logistics Center; it should also be of interest to readers throughout the Army logistics community.

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SUMMARY

This report describes the concept of operations for a U.S. Army combat-oriented Logistics Execution System with VISION (Visibility of Support Options). The VISION Execution System is a decision support system intended to assist logisticians, including theater Army Materiel Management Centers (MMCs) and Army Materiel Command (AMC) Major Subordinate Command (MSC) Inventory Managers (IMs), in managing logistics resources. VISION's intent is to maximize the probability of achieving specific weapon system availability goals over a given time horizon with available resources. Although this study limits its discussion to how a system like VISION could determine the repair and distribution priorities of high-technology reparable spares, the VISION concept can be applied in principle to a much wider range of resources needed to sustain weapon system combat operations.

THE NEED FOR VISION

Army doctrine specifies that Army forces must be prepared to fight in a wide range of potential scenarios, including nonlinear battles. To meet the challenges of this type of warfare and of facing numerically superior forces—such as would probably occur in a NATO conflict—the Army has placed emphasis on acquiring high-technology weapons to achieve a qualitative edge over potential adversaries. This strategy in turn has increased the importance of rear-echelon logistics structures in maintaining combat readiness. In addition, components for high-technology weapons are expensive, and, due to budget constraints, spares may be scarce in both peacetime and wartime environments. Furthermore, demands for these components are difficult to predict in peacetime, and prediction becomes more complicated during wartime.

Because of these problems, differences in the foreseeable future between demands for high-technology components and their availability are likely to occur. The logistics system must assess the effects of these imbalances and determine actions at each echelon to fix reparables and deliver serviceables to the combat units that need them most. The logistics system must anticipate demands for spares to the extent possible, be adaptive to the uncertain requirements of wartime, and respond in a timely way.

VISION's Execution System aims at meeting these logistics needs.

THE DESIGN OF THE VISION EXECUTION SYSTEM

Characteristics of VISION Execution System

The VISION concept uses four key design characteristics:

- Weapon system availability as a measure of merit to focus the actions of each echelon on combat unit needs.
- A short-term weapon system operating tempo requirement for each combat unit to project expected wartime and peacetime demands for individual components.
- Current data on the availability of resources and their status to develop the appropriate execution actions at each echelon.
- A model for prioritizing repairs and distributions. The newly developed DRIVE (Distribution and Repair in Variable Environments) model contains many of the features needed to operate VISION. Although DRIVE does not meet all needs of VISION, it provides a platform that can be modified to meet requirements.

Potential Users and Uses of VISION Execution System

The VISION Execution System can guide repair and distribution actions by logisticians at various echelons. VISION could be used at the depot level to assist MSC/IMs and depot programmers, and at the theater, corps, and division levels to assist Materiel Management Centers (MMCs). These organizations would in turn provide guidance on repair and distribution priorities to Depot Systems Command (DESCOM) repair and storage depots, to theater Specialized Repair Activities (SRAs), depots and storage sites, to corps SRAs and supply points, and to Forward Support Battalion and Main Support Battalion (FSB/MSB) repair and supply operations.

Concept of Operations for VISION Execution System

The many potential VISION users are located in geographically dispersed organizations. This separation, combined with the number of repair and distribution sites, decision echelons, materiel resources, and personnel involved in making decisions for each weapon system, makes it difficult for the Army to build a centralized decision support system to assist the organizations in directing and controlling repair and distribution actions in a benign and steady-state environment. In addition, the dynamics of probable wartime scenarios would further complicate the operation of a centralized system. For instance, the distance

that separates depot facilities from the combat zone and the relatively more sophisticated repairs depots perform create a time lag in the actions taken and the time that serviceable assets show up in the combat zone. In the area of distribution, a responsive system delivering serviceables to the division or corps levels in direct support service could take seven to ten days from continental U.S. (CONUS) supply or repair depots. During this time interval, weapon system goals and priorities of the combat forces would probably change from those that existed when depot distribution decisions were made. As a result, the corps MMCs may wish to reallocate serviceables to combat units with more urgent needs and a division MMC may wish to reallocate assets among FSBs to provide better support to units that are going to engage the enemy in the near term. The problem of coordinating these actions from a central system would be extremely difficult, if not impossible.

As a result, the VISION design concept calls for a series of hierarchical, decentralized decision support systems that take into account differences in repair and distribution responsibilities and responsiveness of the various echelons. Each repair and decision hierarchy could have a VISION Execution System module operating at that echelon. In this concept, each echelon would "look" as far forward as possible to gear repair and distribution decisions at that echelon to maximize forward unit weapon system availability.

Because the sustainability of high-technology weapon systems is directly tied to the supply and repair operations of the Intermediate Direct Support Maintenance (IDSM) organization, the concept of "combat unit" needs to be broadened to include the IDSM organization and all the traditional combat units it services. In the case of the M1, the "combat unit" would include the two or three battalions of M1s served by the FSB. Unit in this report refers to the broader definition.

The VISION Execution System accepts two major categories of inputs—scenario data and logistics data. It then uses a model to produce various outputs for controlling repair and distribution activities.

Inputs to the System. *Scenario data* include weapon system availability goals, current and expected force postures, and anticipated operating tempos over the time horizon being investigated. Weapon system availability goals need to be specified for each of the weapon systems included in VISION. The system has been designed to accept goals for each weapon system which can change depending on the weapon system's importance at specific points in time. In general, these availability goals are established for a unit being serviced by a given IDSM organization.

In addition to the availability goals, the operating tempo for each weapon system unit must be provided for the time horizon of interest. For example, if one were using the VISION system to determine peacetime repair priorities for a given facility, the short-term peacetime operating tempos over the next few weeks, plus an anticipated short-term wartime operating tempo for the units supported by that facility, would have to be supplied. The DRIVE model would use this information to determine the repairs necessary in peacetime for the units to meet both their peacetime and wartime taskings. In wartime application, VISION would use the short-term wartime operating tempo to anticipate needed repairs and distributions.

Logistics data include item characteristics, item indenture relationships, item interchangeables and substitutes, cross references of test equipment used to isolate faults for specific items, test equipment capacities, current asset positions, wartime and peacetime demand rates, order and ship times, repair times, condemnation rates, and the like. The item characteristics data identify the Line Replaceable Units (LRUs) and Shop Replaceable Units (SRUs) or Printed Circuit Boards (PCBs) and describe their behavior. The items are identified by National Stock Number (NSN) and other data, such as National Inventory Control Point (NICP) code and part number.

Outputs of the System. The primary outputs of the VISION Execution System are designed to maximize weapon system peacetime and wartime availability by:

- Projecting short-term priorities of repair actions, given existing resources.
- Providing distribution guidance for serviceable assets.

In addition, the system can be used to project quarterly and yearly forecasts of repair workloads by increasing the time horizon used in generating the forecasts. The longer range forecasts help examine resource requirements needed to achieve alternative levels of weapon system availability. For instance, the MSC/IM might use this capability to provide insights on the level of repair funding necessary to achieve specific levels of weapon system availability. A DESCOM depot might use these estimates to help determine the amount of repair parts needed to fix a given mix of LRUs and SRUs that are required to meet weapon system availability objectives.

POTENTIAL BENEFITS OF VISION

A stream of RAND research has shown that alternative logistics support concepts that couple responsive repair and distribution capabilities with a VISION-like management system can significantly improve weapon system support. For instance, a system that can prioritize repairs and distributions at each echelon and quickly move spare parts to where they are needed could improve the availability of a corps of M1 tanks by approximately 30 percent over the current system, using the same amount of high-technology reparable spares and associated test equipment. The additional cost to "buy out" the stock needed to achieve the same weapon system availability, using the current execution system, was estimated to be over $230 million for one corps of M1s through 120 days of the war scenario. The additional cost for the responsive system that would provide the same improvement in M1 availability through more rapid transportation and repair was estimated to be approximately $50 million over the same 120 days, or less than 25 percent of the stock buy out option.

This research provides insights on the potential worth of a VISION Execution system. For the limited case cited above, one might be willing to pay up to $180 million ($230 million less $50 million) to build a VISION Execution System to serve the needs of this corps. Because VISION could be used to support a large number of weapon systems, the worth of the system could be significant and warrant fairly large outlays to develop. In addition, a VISION Execution System could provide the basis for dealing with uncertainty in a more flexible fashion than the purchase of additional stocks would allow.

In the research cited above, the contributions of an execution system with VISION characteristics to improved weapon system support have not been separated from the effects of faster transportation and repair. Before a VISION system is built, more research is needed to separate these contributions and specifically identify the costs and benefits associated with a VISION Execution System.

RECOMMENDATIONS

The Army should develop prototypes of VISION in two phases: demonstration and operational. Because VISION differs greatly from the current system, prototypes are necessary to prove the concept and to develop detailed design specifications used to produce the system. Prototypes should be developed for use at each echelon where the system is being considered for application.

If evaluations of the initial prototypes indicate further development is warranted, successive increments of VISION should then be built to expand the number of resources and weapon systems covered. Each of these prototypes should be developed in less than one year. If successful demonstration and detailed cost-benefit analyses so warrant, each increment should be considered for full-scale development and implementation. This prototyping and incremental development strategy reduces the risks associated with large-scale system development efforts and allows the system to expand on an evolutionary and well-controlled basis.

For VISION to reach its full potential, existing Logistics Management Systems (LMS) would have to be modified or new ones developed. By following the development strategy outlined above, it is hoped that VISION would serve as important input into a U.S. Army strategic plan for the modernization of logistics management systems.

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The authors would like to express their appreciation to several of their RAND colleagues for helping to shape the ideas contained in this report. William Stringer and Patricia Boren expressed valuable thoughts on how Army Logistics Management Systems could be used or modified to supply the data requirements for VISION. Irving Cohen provided insights on the logic for the functions and purposes of VISION. Thomas Lippiatt, Irving Cohen, and John B. Abell shared early thoughts on the concept of tying logistics operations at all echelons to the dynamic needs of combat forces. Jack Abell and Louis Miller performed the pioneering research that led to the development of the DRIVE (Distribution and Repair in Variable Environments) model providing the basis for a system like VISION. Raymond Pyles and Louis Miller reviewed drafts of this report and provided valuable guidance on how the material should be presented. C. L. Batten and Alvin Ludwig helped organize the document and clarify the expression of ideas. Susan Baugh, Carol Zaremba, and Elizabeth Sullivan prepared several drafts of the manuscript in the preparation of the final report. Mr. Jeffrey Crisci of the Army Materiel Command and Captain Susan Junker and Mr. Greg Kropp of the Army Logistics Center were instrumental in providing contacts and access to Army data and facilities that were important in shaping the ideas found in VISION.

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ABBREVIATIONS

AMC	Army Materiel Command
AMCCOM	Armament, Munitions, and Chemical Command
AMSAA	Army Materiel Systems Analysis Activity
ASL	Authorized Stockage List
ATCCS	Army Tactical Command and Control System
AVIM	Aviation Intermediate Maintenance
BN	Battalion
CCSS	Commodity Command Standard System
CONUS	Continental United States
CSSCS	Combat Service Support Control System
C^2	Command and control
DESCOM	Depot Systems Command
DRIVE	Distribution and Repair in Variable Environments
DSESTS	Direct Support Electrical Systems Test Set
EAC	Echelons Above Corps
EQUATE	Electronic Quality Assurance Test Equipment
FMC	Fully Mission Capable
FSB	Forward Support Battalion
IDSM	Intermediate Direct Support Maintenance
IM	Inventory Manager (NICP)
IPD	Issue Priority Designator
LIF	Logistics Intelligence File
LRU	Line Replaceable Unit
MCC	Movement Control Center
MMC	Materiel Management Center
MSB	Main Support Battalion
MSC	Major Subordinate Command (Commodity Command)
NICP	National Inventory Control Point
NMP	National Maintenance Point
NSN	National Stock Number
OSS	Objective Supply System
PCB	Printed Circuit Board
PN	Program Notice
PPBES	Planning, Programming, and Budget Execution System
PWD	Procurement Work Directive
SARSS	Standard Army Retail Supply System
SDC	Sample Data Collection
SDS	Standard Depot System
SLAC	Support List Allowance Computation

SOR	Source of Repair
SRA	Specialized Repair Activity
SRU	Shop Replaceable Unit
TACOM	Tank and Automotive Command
TPS	Test Program Set
TRADOC	Training and Doctrine Command
TSTS	Thermal System Test Set
UMMIPS	Uniform Materiel Movement and Issue Priority System
VIC	Vector in Commander
VISION	Visibility of Support Options
WSMAP	Weapon System Management Action Plan
WSMIS	(Air Force) Weapon System Management Information System

I. INTRODUCTION

This report describes a decision support system designed to help U.S. Army logisticians manage resources and improve the availability of high-technology weapon systems in both peacetime and wartime environments. The concept presented here is called the VISION (Visibility of Support Options) Execution System. It is a combat-oriented decision support system that addresses the serious problem of sustaining the operation of sophisticated and expensive weapon systems in both peacetime and wartime by improving management of their high-technology reparable components. Although this report limits discussion to how a system like VISION could improve the management of high-technology reparable spares, the concept can apply in principle to a much wider range of resources needed to sustain weapon system combat operations.

PROBLEMS OF CURRENT LOGISTICS MANAGEMENT

To understand the need for a VISION Execution System, one must consider the likely operating environments that the Army could face in the foreseeable future. As outlined in the Army Operations Field Manual, the Army must be prepared to fight in a wide range of potential scenarios, from small contingency operations to full-scale global warfare.[1] Within this range of scenarios, perhaps the most difficult is a high-intensity dynamic conventional war like that envisioned in a NATO conflict.

To meet the challenges involved in this type of warfare, the Army has placed growing emphasis on acquiring high-technology weapon systems that will help achieve a qualitative edge over the larger number of weapon systems used by potential adversaries. Such modern weapon systems as the M1 Abrams tank, M2/3 Bradley fighting vehicle, and AH-64 Apache helicopter contain technically sophisticated and highly integrated subsystems composed of computers and other complex electronic and electro-optical equipment that perform many of the mission essential functions, such as acquiring targets in daytime or nighttime, determining target rate of movement and range, and controlling firing

[1]Field Manual No. 100-5, *Operations*, Headquarters, Department of the Army, Washington, D.C., 5 May 1986.

mechanisms. When these high-technology subsystems fail, the combat value of the weapon system is substantially reduced.[2]

Therefore, the Army places great importance on the ability of the logistics system to keep high-technology components on these weapon systems operable.[3] To this end, the Army has emphasized that the weapon systems be designed so that failed components of their mission essential subsystems can be quickly identified and replaced to minimize down time. After removal, these components—Line Replaceable Units (LRUs)—are evacuated to rearward locations to be fixed. This strategy in turn increases the importance of rear echelon logistics structures in maintaining combat effectiveness.

In attempting to provide the right number and mix of serviceable components necessary to keep high-technology weapon systems operational, rear echelon logisticians have to confront four main problems:

- Uncertainty of demands in wartime and peacetime operations.
- Complexity of the logistics process.
- Lack of integration among echelons.
- High costs of components.

The goal of the VISION Execution System is to help logisticians mitigate the effects of these problems by giving them the capability to anticipate needed support over a short time horizon and by being adaptive enough to respond to unexpected new priorities. Such a system would provide the high-technology component support necessary to keep modern weapon systems operational.

Uncertainty of Demands in Wartime and Peacetime Operations

Wartime Operations. In highly dynamic and intense scenarios like those envisioned in a European theater, Army forces can be expected to engage large enemy forces equipped with highly lethal and sophisticated weaponry. In these kinds of scenarios, as outlined in the Army Operations Field Manual, Army forces must be prepared to wage campaigns of considerable movement to reduce vulnerability and to

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[2]For example, if an M1 tank were to lose its laser rangefinder, it would operate with approximately two-thirds of its combat effectiveness. (Personal communication from Walter Clifford, Division Chief, Air Warfare Division, Army Materiel Systems Analysis Activity (AMSAA).)

[3]In fact, the Combat Support Services (CSS) Manual indicates that the primary objective of CSS organizations is to make available as many fully mission capable weapon systems as possible. See *Combat Service Support*, Field Manual 100-10, Headquarters, Department of the Army, Washington, D.C., 18 February 1988.

obtain positional advantage over the enemy. The enemy can be expected to engage in similar strategies and tactics. As a result, battles could be nonlinear in nature. These types of actions could blur the distinctions between front and rear areas. To succeed, Army forces will need to move rapidly to isolate enemy forces of lesser advantage in both rear echelons and forward areas. Attack and defensive operations will probably occur concurrently as the combatants attempt to gain the advantage.

In this kind of environment, the priorities and taskings for particular units will change frequently. Support priorities can be expected to shift rapidly from units in one geographical location to those in another. Also, the nature of the taskings can be expected to influence the type of support needed as units move from offensive to defensive postures and back to the offensive as the flow of battle dictates. For instance, frequent changes in combat unit taskings and resultant priorities for support could cause variance in the demands for items among units dispersed over many locations. Much more demanding and different operating conditions would probably contribute to greater demands for items than had been planned when resource requirements were estimated.

It is also highly probable that enemy actions will inflict damage on support units within the theater. For example, spare parts could be destroyed in some sectors of the theater but might be available in others. Similarly, repair capability could be reduced in some locales as a result of the destruction of test equipment, but could remain unaffected in other locales. The effects of this "damage distribution" are difficult to forecast with an acceptable level of precision, although it is likely that the damage could result in unanticipated demands for high-technology spare parts and associated repair capability.

In supporting operations with this degree of dynamic change, Army doctrine recognizes the need for logisticians to:

- Anticipate support needs to the extent possible
- Respond quickly to changing needs
- Adapt to meet unanticipated requirements that can result from losses of supplies or repair resources after enemy attack.

In these environments, logisticians need a decision support system to help them "drive" workloads through repair shops and distribute serviceables to the units that need them most. The system should determine when it is desirable to provide lateral supply and/or repair capability from forward units or from higher echelons.

Peacetime Operations. Recent RAND research has shown considerable variability associated with "demand distributions" for high-technology components during peacetime operations.[4] Demands for individual high-technology parts vary among locations and time periods. Demands also exhibit different patterns under varying operating tempos. The degree of variability makes it difficult to forecast demands and corresponding inventory requirements for these components with an acceptable degree of precision, even in a peacetime environment.

Complexity of the Logistics Process

Managing the portion of the logistics system that provides the high-technology components necessary to meet Army requirements for weapon system availability is a complex, demanding, and interactive process. Logistics managers at several echelons control thousands of resources and many processes in delivering support to the combat forces. Among others, personnel at the Forward Support Battalion (FSB), Division Materiel Management Center (MMC), corps MMC, theater MMC, and Army Materiel Command (AMC) Major Subordinate Commands (MSCs) support the M1. Each one can affect the number of resources including LRUs, Shop Replaceable Units (SRUs), Printed Circuit Boards (PCBs), bench stocks composed of "bits and pieces," and test equipment at each location in the system. These personnel and others at Depot Systems Command (DESCOM) also control the priorities for repair and procurement actions at their respective echelons. MSC, MMC, and Movement Control Center (MCC) personnel control the movement of high-technology components throughout the system.

Figure 1.1 illustrates how these organizations interact to provide support for a weapon system like the M1. The FSB repair shop uses test equipment to identify the PCBs that cause LRUs to fail. Once it isolates faults to particular PCBs, the FSB replaces the PCBs and returns the LRUs to either the Authorized Stockage List (ASL) supply operation or the inoperable weapon systems. The faulty PCBs are sent to higher echelons, which identify faults in the PCBs and replace failed items such as resistors, transistors, and computer chips. If the FSB cannot isolate the fault, it evacuates the LRUs to higher echelons for repair.

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[4]M. B. Berman, D. W. McIver, M. L. Robbins, and J. Schank, *Evaluating the Combat Payoff of Alternative Logistics Structures for High-Technology Subsystems*, The RAND Corporation, R-3673-A, October 1988. Also see Gordon B. Crawford, *Variability in the Demands for Aircraft Spare Parts: Its Magnitude and Implications*, The RAND Corporation, R-3318-AF, January 1988.

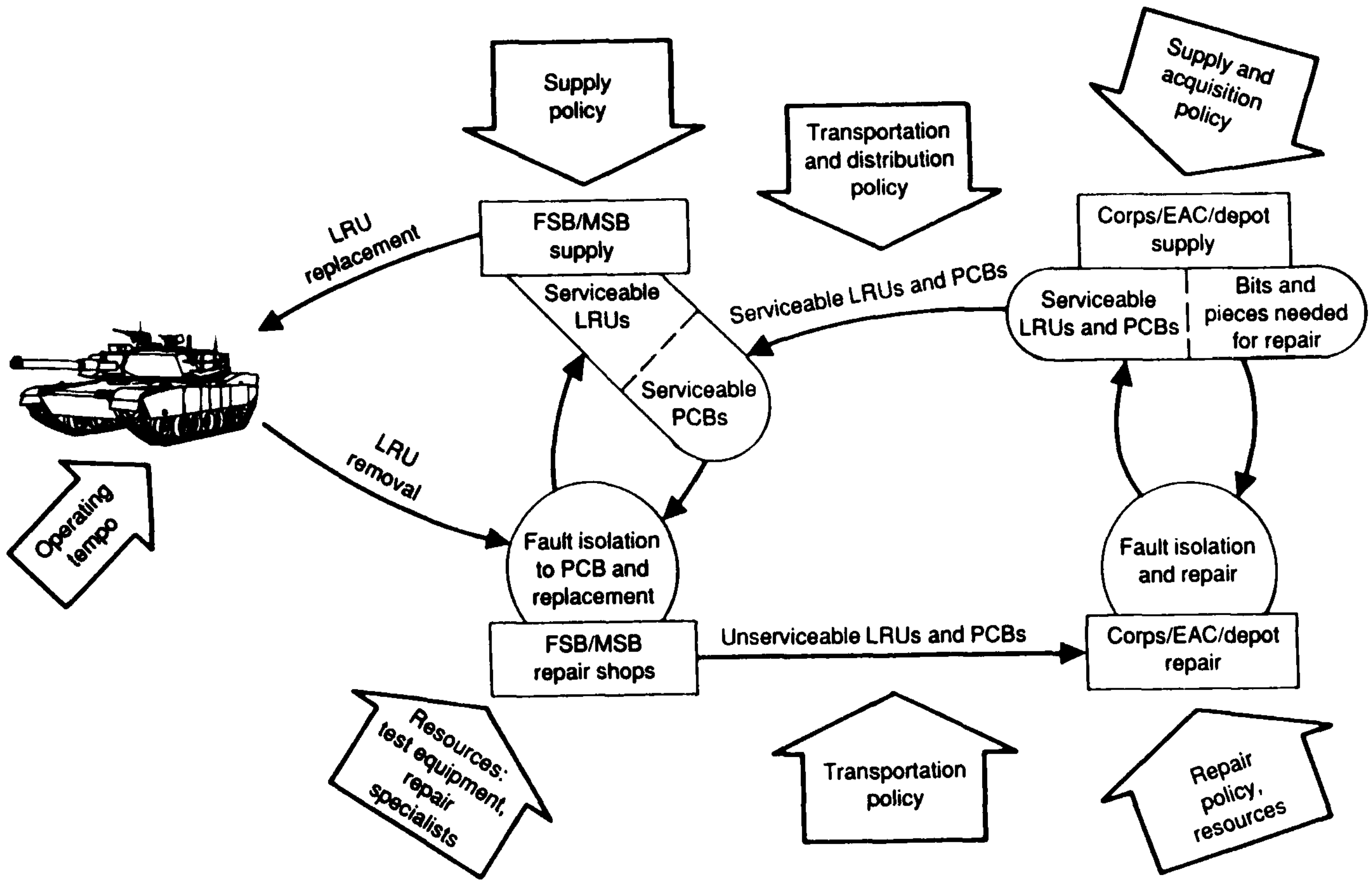

Fig. 1.1—Support environment for M1 tank

Weapon system support thus depends directly on both specific forward and rear echelon logistics actions. Although these relationships are well defined and understood, they are nonetheless complex and do not always run efficiently. As the thick arrows in Fig. 1.1 suggest, by changing policies and procedures, the system can be manipulated. Among other things, the policies and procedures can affect the number and speed of parts as they flow through various points in the system.

Lack of Integration Among Echelons

The Army must ensure that weapon systems can meet their peacetime operating requirements and wartime commitments. As we have just shown, managing the actions that ensure weapon system availability is difficult because so many processes and organizations influence the delivery of support. But there is an additional problem: Because of the size and complexity of operations, the functions at each echelon have evolved so that each operates relatively independently, providing little feedback on how operations at one echelon affect those at another. Furthermore, measures for assessing how each function performs tend to look at the efficiency or effectiveness of that function alone and not at how that function interacts with others to produce combat capability. For instance, MSC Item Managers (IMs) provide stock levels to meet an average backorder objective at the depot. Transportation personnel attempt to minimize transportation costs while meeting the time standards established by the Uniform Military Movement and Issue Priority System (UMMIPS). DESCOM repair schedules are negotiated based on the availability of funds, current requisitioning priorities of assets, and efficiency of production runs.

It is difficult to determine how degradations in these measures affect weapon system readiness in peacetime environments. It is even more difficult for managers to know how the decisions they make in peacetime would affect weapon system availability in wartime. Currently, no management system provides feedback on how its decisions would affect weapon system availability in wartime. Logistics managers at each echelon need an information and decision support system to help them integrate functions and execute decisions in peacetime that will maximize wartime weapon system capability.

High Costs of Components

The high costs of components further complicate repair and distribution processes. If broken LRUs and their subcomponents (PCBs or

SRUs) were relatively inexpensive (as were components in previous generations of Army weapon systems), then one might buy enough additional components and subcomponents to overcome reliance on an integrated supply and maintenance system. However, sophisticated components are usually more expensive, often by orders of magnitude.

Table 1.1 shows the costs of some of the high-technology LRUs embedded in the M1 and AH-64 weapon systems.

Such high costs make "buying our way" out of the problem difficult, and it becomes even more difficult when we also consider not only the high costs of the Test Measurement and Diagnostic Equipment (TMDE) required at all echelons, but also the difficulty of obtaining sufficient numbers of highly skilled personnel required to repair LRUs and PCBs. Thus, in terms of total costs, buying repair components to support the current logistics structures is many times more expensive than it would be for more traditional and less technologically sophisticated components.

Table 1.1

TOP TEN ELECTRONICS LRUs BY UNIT COST IN APACHE AND M1

Apache helicopter	
Night sensor assembly	$164,767
PNVS turret assembly	161,480
TADS turret assembly	150,082
Day sensor assembly	150,082
TADS electronic unit	89,069
Optical relay column	87,141
Laser transceiver unit	63,134
HARS	62,400
MRTU Type III	42,446
Television sensor assembly	39,018
Abrams M1 tank	
Thermal receiver unit	$76,019
Power control unit	56,359
GPS [illegible]dy assembly	51,067
Computer	10,337
TIS electronic unit	13,015
Laser rangefinder	22,270
Turret networks box	17,209
TIS image control unit	11,123
Gun turret drive electronics	6974
Servomech traverse	5729

SOURCE: Army Master Data File, 1988.

Because of the cost of high-technology components, budget pressures could limit the availability of these components. As a result, high-cost high-technology components are likely to be in short supply.

In short, the Army needs a decision support system that addresses the complexity and problems of the current logistics procedures for ensuring weapon system availability in both peacetime and wartime. It especially needs a system that could help prioritize repair and distribution decisions for reparable items in technologically sophisticated weapon systems, like those in the M1. Such a system must help logisticians execute integrated support actions, and it must incorporate mechanisms that make it more responsive to unanticipated demands that result from uncertainties.

CONCEPT FOR AN INTEGRATED AND RESPONSIVE EXECUTION SYSTEM

This report proposes a concept for a logistics decision support system that addresses the needs outlined above, especially for an integrated and responsive execution system that can meet uncertainties in demand. This concept, the VISION Execution System, is designed to help Army logisticians better manage support for high-technology weapon systems. In particular, this system can help prioritize repair and distribution decisions for reparable items. It could be used to adjust support actions quickly at each echelon, including the depot level, and therefore meet the changing and unanticipated demands for high-technology components in both peacetime and wartime environments.

The VISION Execution System will not fundamentally change the logistics management structure or organization. Rather, it is an improvement to the present execution system for scheduling repair workloads and distributing components.

MEETING THE ARMY'S NEED FOR IMPROVED LOGISTICS MANAGEMENT

The Army has perceived and expressed a need for improving its logistics management. Indeed, Army Doctrine expresses the need for a decision support system like VISION at the field level.[5] Recently,

[5]See Army Field Manuals 100–5, *Operations*, 5 May 1986; 63–2, *Combat Service Support Operations—Division*, 21 November 1983; 100-10, *Combat Service Support*, 18 February 1988; 63–35, *Combat Service Operations—Corps*, 12 August 1985; 63–5, *Combat Service Support Operations—Theater Army*, 22 February 1985, Headquarters, Department of the Army, Washington D.C.

attention has also turned to the need to relate how wholesale logistics decisions affect combat capability. The Weapon System Management Action Plan (WSMAP) developed some of the Army's ideas at the wholesale level for a better decision support system.[6] As part of this plan, AMC has identified the need to improve asset visibility at the wholesale and retail levels, as well as the need to relate logistics resource levels to measures of weapon system capabilities. In addition, difficulties in supporting the Apache weapon system with needed spare parts reinforced this view and placed emphasis on providing improved asset visibility at all echelons of support. The Objective Supply System (OSS)[7] effort being undertaken by the Army Materiel Command and supported by the Training and Doctrine Command's (TRADOC) Logistics Center is a manifestation of the interest in obtaining asset visibility at both the retail and wholesale echelons of supply.

The concept outlined here builds on ideas contained in these efforts. With respect to WSMAP, the VISION Execution System outlines the specific information needed to relate logistics resources and process performances to weapon system availability objectives for high-technology reparable components. The VISION Execution System also provides a framework to define initial WSMAP development objectives. It could help develop priorities for enhancing logistics information systems required to implement WSMAP so that the systems respond to the needs of the force in peacetime and wartime environments. With respect to OSS, VISION shows how asset visibility, along with other combat and logistics information, can help determine and enhance weapon system combat capability.

Successive expansions of VISION could provide direction and priorities for the development of WSMAP objectives and be a useful input into an Army strategic development plan for logistics management information systems.

In a related effort, the Logistics Center is developing extensions to the Standard Army Retail Supply System (SARSS) to provide visibility of assets in Authorized Stockage Lists (ASLs) to division, corps, and theater. The VISION concept calls for this level of visibility to be provided to the National Inventory Control Point (NICP) as well.

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[6]*See Army Implementation of DoD Weapon Systems Management Action Plan*, Department of the Army, Assistant Secretary for Installations and Logistics (I&L), 27 March 1986. This document was developed by the Army Materiel Command (AMC) to implement the DoD Weapon System Management Concept for Secondary Items. See *Secondary Item Weapon System Management Concept and Implementation Plan*, Office of the Secretary of Defense, April 1986.

[7]The Objective Supply System briefing by the Army Logistics Center to General Wagner and General Thurman, 25 January 1988.

The VISION concept extends recent work done by RAND on evaluating alternative logistics structures for the Army.[8] The work indicates potentially significant combat advantages and clear cost advantages that result from a system such as VISION. It analyzes the costs associated with "buying out" sufficient inventory stocks for high-technology components to provide an availability goal of 80 percent for a corps of M1s.[9] It also estimates the upper bound on the worth of a "VISION-like" execution system. The RAND study finds that a responsive system that uses fast transportation and repair capabilities and an execution system like VISION, one with "perfect visibility" of the repair and distribution actions at each echelon, would meet the 80 percent availability goal for a cost that is $180 million less than the cost of buying out stocks needed to achieve the same weapon system availability objective using the current execution system.[10] The study includes estimates of the cost of providing more rapid transportation and repair capabilities, but did not include costs necessary to develop a VISION Execution System. Extrapolating these benefits across all M1 units and other weapon systems indicates such a system could have significant benefits and provide justification for making fairly large expenditures to develop a VISION system.

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[8]M. B. Berman et al., October 1988.

[9]This analysis used a European scenario similar to that employed in the P90E Concepts Evaluation Model developed by the Concepts Analysis Agency.

[10]Section IV of this report summarizes the details of the alternative structures study relevant to understanding the costs and benefits associated with a responsive execution system.

II. THE STRUCTURE OF THE VISION EXECUTION SYSTEM

The VISION Execution System is a decision support system intended to assist logisticians, including Theater Army Materiel Management Centers (MMCs), corps MMCs, division MMCs, and Major Support Command Inventory Managers, in determining repair and distribution priorities for mission-essential high-technology components at their respective echelons. The intent is to determine the priority sequence of repair and distribution actions at each echelon to maximize the probability of achieving specific weapon system availability goals over a given time horizon with available resources.

CHARACTERISTICS OF THE PROPOSED VISION EXECUTION SYSTEM

To achieve the objectives of the VISION Execution System, the system concept incorporates several key characteristics:

- Weapon system availability as a measure of merit.
- Short-term operating tempos to project component demands.
- Current asset data to develop execution actions.
- A model to project repairs and distributions.

As pointed out later in this section, some modification of existing Army logistics information systems would be needed if VISION were to be implemented. In addition, existing models would have to be modified and extended somewhat.

Weapon System Availability as the Measure of Merit

First, the system uses a single measure of merit—weapon system availability—to determine repair and distribution actions at each echelon and to ensure that forward and rear echelons provide coordinated and effective support. The system projects the repair and distribution actions that should take place within a given time horizon to maximize the probability that all combat units will achieve specific peacetime and wartime weapon system availability objectives. To meet the needs of logisticians who provide support actions in dynamic wartime environments, the system should accept different weapon system

availability goals for each weapon system or specific combat unit. These frequently changing goals should be entered into the system whenever desired. The Army has recognized the importance of adopting an integrating measure of merit to direct and control logistics actions at all echelons, and the Army Weapon System Management Action Plan and Combat Service Support Operations Manuals have adopted weapon system availability as the integrating measure.[1]

Short-Term Operating Tempos To Project Component Demands

Second, the system uses short-term weapon system operating tempo requirements for each combat unit to project expected wartime and peacetime demands for individual components. Recognizing the difficulties associated with forecasting demands for high-technology components, the system keeps the time horizon used to forecast priorities for repair and distribution actions as short as possible and estimates demands that will occur during this interval. The system attempts to *anticipate* support requirements over a short time horizon to gear actions to important combat operations. Forecast errors will inevitably take place. As a consequence, the time horizon is kept small so that forecast errors do not get large. These operating tempos, like the availability goals, can be changed at any time to reflect changing requirements.

Current Asset Data To Develop Execution Actions

Third, the system uses data on current resources and their status to develop the appropriate execution actions at each echelon. Accurate reporting of the number and condition of assets at each echelon, as well as the status and capability of repair and transportation resources, must be made on a frequent basis. This visibility can compensate for the inability to accurately predict demands for high-technology components in wartime and peacetime environments. Knowing the current status of assets at each combat unit, supply unit, and repair unit can help determine the short-term priorities for repairs and distributions

[1]See *Army Implementation of DoD Weapon Systems Management Action Plan*, Department of the Army, Assistant Secretary for I&L, 27 March 1986; and *Secondary Item Weapon System Management Concept and Implementation Plan*, Office of the Secretary of Defense, April 1986; and *Combat Service Support*, Field Manual 100-10, Headquarters, Department of the Army, Washington, D.C., 18 February 1988. See also Field Manuals such as 63-3J, *Combat Service Support Operations—Corps*, which indicate that weapon system availability is an important goal and establishes a weapon system focal point in the corp MMC.

needed to maximize weapon system availability at each unit. This feature will allow the system to *adapt* to unexpected events and *respond* with appropriate actions. For instance, if serviceable stocks are damaged but needed by a combat unit at one location, the system can initiate actions to replace the stocks required by that unit. The system needs to assist logisticians in determining if those stocks should be replaced by taking lateral resupply actions, or if direct support actions from higher echelons can satisfy the needs in the required time frame. This information on damaged stocks is needed at higher echelons so that distribution of reparable carcasses and repair actions can be initiated to make up for the losses.

A Model To Project Repairs and Distributions

Fourth, the system requires a model to project the sequence of repairs and distributions that would maximize the probability of meeting weapon system availability goals, given the current status of existing resources and short-term operating requirements at each unit. A new model—the DRIVE (Distribution and Repair in Variable Environments) model—has many features necessary to perform these functions.[2] As discussed later, the current version of DRIVE does not satisfy all modeling requirements needed in VISION, such as projecting necessary lateral support actions and coordinating the effects of decisions made at one echelon with those made at others. It does, however, provide a basis that can be modified to meet specific Army application requirements.

THE NEED TO COORDINATE THE DECENTRALIZED ACTIONS OF SEVERAL ECHELONS

Weapon system availability is affected by the many geographically dispersed organizations that make repair and distribution decisions. These organizations include FSBs, Main Support Battalions (MSBs), Division MMCs (DMMCs), corps MMCs and MCCs, theater MMCs and MCCs, NICPs, and depots. The geographical separation, combined with the number of repair and distribution sites, decision echelons, materiel resources, and personnel involved in making decisions for each weapon system, poses serious challenges to any centralized decision support system assisting these organizations in a benign

[2]The work to develop DRIVE has been sponsored by HQ USAF and HQ Air Force Logistics Command (AFLC). The algorithm has been developed and tested at the Ogden Air Logistics Center. A RAND report describing DRIVE is being prepared.

and steady-state environment. In addition, the dynamics of probable wartime scenarios would further complicate the operation of a centralized system. For instance, the distances that separate depot facilities from the combat zone and the nature of the relatively more sophisticated repairs they perform create a time lag in the actions they take and the time that serviceable assets show up in the combat zone. As for distribution, a responsive system that delivered serviceables to the corps in direct support service could take seven to ten days from CONUS supply or repair depots. During this time interval, weapon system goals and priorities of the combat forces may change from those that existed when the depot made its distribution decisions. As a result, the corps MMCs may wish to reallocate serviceables to combat units with more urgent needs, and a DMMC may wish to reallocate assets among FSBs to provide better support to units that will engage the enemy in the very near term. The problem of coordinating these actions from a central system would be extremely difficult, if not impossible.

As a result, the VISION design concept calls for a series of hierarchical, decentralized decision support systems that take into account differences in repair and distribution responsibilities and responsiveness of the various echelons and functions. Each decision hierarchy would have a VISION Execution System module operating at that echelon. In this concept, each echelon would "look" as far forward as possible to gear repair and distribution decisions to maximize forward unit weapon system availability. Decisions must be made on how far forward each echelon should look to maximize weapon system availability. In other words, what "combat unit" should each echelon be gearing its activities to support?

The definition of what comprises a "unit" needs to be reexamined for high-technology weapon systems. As Sec. I showed, the effectiveness of high-technology weapons depends on properly functioning sophisticated electronic and electro-optical components. When they fail, the components must be replaced and repaired rapidly. However, the high-technology systems and associated components are held in ASLs that are collocated with the Intermediate Direct Support Maintenance (IDSM) organization. The IDSM organization may serve many combat units. Depending on the weapon system, these organizations have different names and support different numbers of weapon systems organized in a number of combat units. For example, the FSB is the IDSM organization that supports a number of M1 and M2/3 battalions. The Aviation Intermediate Maintenance (AVIM) squadron supports a number of AH-64 companies.

Because the sustainability of these high-technology weapon systems is directly tied to the supply and repair operations of the IDSM organization, the combat unit needs to be broadened to include the IDSM organization and all the traditional combat units it services. In the case of the M1, the combat unit would include the two or three battalions of M1s served by the FSB.

Conceptually, each echelon could attempt to gear its decisions to maximize weapon system availability at the unit level. Recognizing that circumstances may change after higher echelons make these decisions, some lower echelons may need to make reallocations based on more current information. This is the VISION design approach described in the next section. It must be tested in a prototype environment and modified if necessary based on information gained during the operation of the prototype.

To illustrate how VISION could be embedded at each echelon, Fig. 2.1 shows the organizations that could use VISION systems to direct and control the repair and distribution workloads associated with the

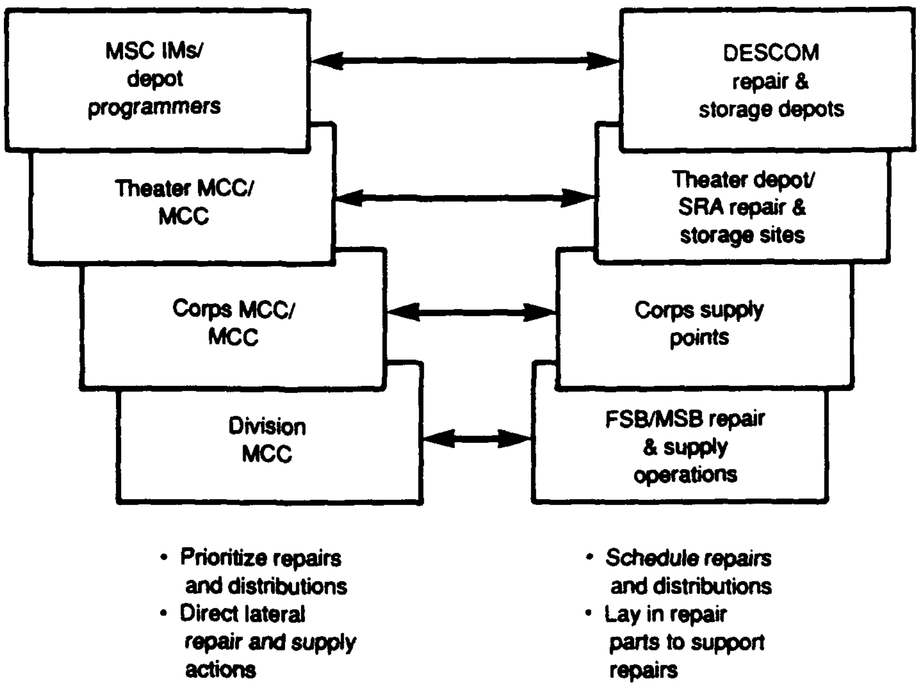

Fig. 2.1—Uses of VISION Execution System to support M1/M1A1/M2/3 weapon systems

M1/M1A1/M2/3 weapon systems. In general, the organizations named in the blocks on the left of the figure could all use local VISION systems to provide guidance on repair and distribution priorities to the organizations named in the blocks on the right. For instance, the MSC IMs, through their depot programmers, provide repair and distribution priorities to the appropriate DESCOM depots to maximize the availability of weapon systems supported by the FSBs/MSBs during a specific time horizon. The organizations on the right, in general, receive guidance from the organizations on the left and take the appropriate action. Section III describes how these organizations could use VISION at each echelon.

THE COMPONENTS OF THE SYSTEM

As indicated above, the VISION Execution System is a series of hierarchical decision support systems that guide repairs and distributions to maximize "unit" level weapon system availability. Each local VISION module considers the weapon systems and items that are supported by that decision echelon. For instance, a particular division may have M1s and M2/3s supported by several FSBs, an MSB, and a range and depth of stocks in its ASL. A VISION module for this division would need information on the M1 and M2/3 weapon system availability goals, short-term peacetime and wartime operating tempos, item characteristics and availabilities within its ASL, repair times for reparable items, and repair capacities for the repair units that fix a range of these items (e.g., amount of Direct Support Electrical Systems Test Set (DSESTS) time available). As another example, consider the MSC IMs whose items are repaired at the electro-optics shop at the Sacramento Army Depot. This shop repairs items managed by several IMs located at different MSCs and used on several weapon systems. In addition, serviceable assets are stored at several storage depots around the world. To help the IMs make repair and distribution decisions, a VISION module needs data on weapon system goals and operating tempos; item characteristics and availabilities at the unit ASLs, storage depots, and repair sites; and repair times for each item and the capacity of the Sacramento shop to handle all repairs.

Figure 2.2 provides an overview of the major inputs, model processing, and outputs for each local VISION system. The figure shows that the system accepts two major categories of information—scenario information (top of figure) and logistics information (left side of figure). A derivative of the DRIVE model then uses this information to sequence repair and distribution actions. The remainder of this section briefly describes the components of the local VISION systems.

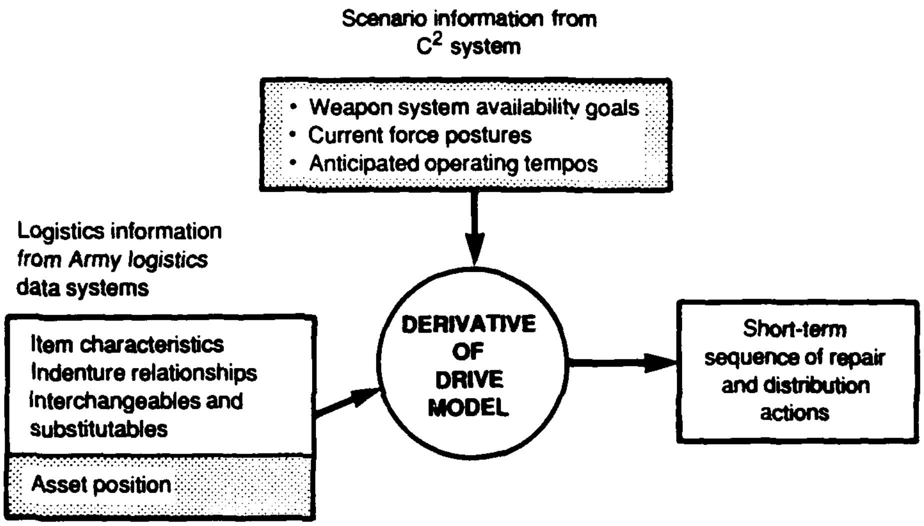

Fig. 2.2—VISION Execution System overview

Scenario Information

As shown at the top of Fig. 2.2, the system accepts three categories of *scenario information:*

- Weapon system availability goals
- Current force postures
- Anticipated weapon system usage rates or operating tempos.

The VISION Execution System needs weapon system availability goals for each weapon system it supports. These goals can change depending on the weapon system's importance at specific points in time. In general, availability goals are established for a "unit" being serviced by a given Intermediate Direct Support Maintenance (IDSM) organization.[3] Each unit can be a standard configuration usually serviced by an IDSM organization, such as three M1 battalions in an armored division serviced by an FSB, or it can be a special mix of forces composed for a given special mission. This feature allows a given IDSM organization

[3]The IDSM concept and organization depends on the type of weapon system being supported, and is tailored to meet the needs of specific weapon systems. As examples, FSBs have the test equipment, spares, and personnel to meet the support needs of M1s and M2/3s. The Aviation Intermediate Maintenance (AVIM) squadrons have support equipment and personnel to meet aviation intermediate repair needs.

to "pick-up" weapon systems from other organizations rendered ineffective at any given time in a war scenario.

In addition, the VISION Execution System needs information on the number of weapon systems being supported by an IDSM and a means of identifying the general geographical locations of the IDSM organization.

Finally, the VISION Execution System needs estimates of the operating tempo or weapon system usage rate for each weapon system unit for the time horizon of interest. For example, if one were using the VISION system to determine peacetime repair priorities for a given facility, one would need the short-term peacetime operating tempos plus an anticipated short-term wartime usage rate for the units supported by that facility.[4] In peacetime applications, the short-term wartime usage rates could be "representative," based on expected wartime operation for a given unit. For example, some units could have 15 to 30 days of tempo, reflecting attack operations, whereas others might have light defensive tempos or some combination of operating tempos. The DRIVE model can use this information to determine peacetime repairs for the units to meet both their peacetime and wartime taskings. In wartime applications, the short-term operating tempo would reflect wartime expected taskings during a given time frame.

Figure 2.2 also shows that local VISION Execution System modules anticipate receiving these data from a logistics command and control (C^2) system. Currently, such a system does not exist. Until such time as these data can be routinely generated by combat commanders and collected by a C^2 system, they can be collected by hand and entered into the input file.

Logistics Information

The major categories of logistics information needed by VISION include:

- Item characteristics
- Indenture relationships
- Interchangeables and substitutes
- Test equipment used to isolate faults for specific items
- Current asset positions.

[4]The length of the short-term wartime scenario would depend on the echelon that VISION was supporting. For instance, the short-term wartime operating tempo could be 15 days for a division, 30 days for a corps, and 60 days for a depot.

The item characteristics identify LRUs, SRUs, and PCBs by National Stock Number (NSN) and other data, such as NICP code and part number. They also describe the behavior of the items, including wartime and peacetime demand rates, order and ship times, repair times, condemnation rates, and the like.

Indenture relationships show the relationships of items to one another and to the weapon system. This information determines subassemblies needed to make a serviceable LRU and LRUs needed to make the weapon system operational. Coupled with current asset status information at each FSB and higher echelons, these indenture relationships can be used to estimate repair priorities that will produce the highest number of available weapon systems at each unit. This status information should identify PCBs that cause each LRU to be nonserviceable. The status information for each FSB needs to be transmitted to the echelon that repairs the PCBs.

In addition, the system needs information on items that are interchangeable or that can be substituted with one another. This "visibility" of asset status is critical to the effective allocation of repair and distribution actions.

To develop priorities for the repair of LRUs and PCBs, information is needed to identify items that can be tested on specific test equipment at each echelon. For example, the system needs to know the specific LRUs that cross the Thermal System Test Sets (TSTS) test stand and PCBs that cross the Electronic Quality Assurance Test Equipment (EQUATE) at Sacramento Army Depot. In addition, the system needs to know test stand capacities in terms of available test hours and the test time for each item that crosses the stand. This information is used with other elements to determine the cost of repair. Used with information about the value of a repair to weapon system availability, it will help define a priority sequence of repair actions.

VISION must have information on the number of serviceable assets and reparable carcasses that are available at each site. The system uses this information to determine the repairs and distributions that should take place to maximize the probability that all units will meet their availability goals. The system uses this current information of asset status to cope with unanticipated events as they occur. In other words, the system emphasizes using current information about what is available, rather than using long-term forecasts that are prone to error, to determine repair and distribution priorities.

The VISION Execution System Model

The VISION Execution System model is an algorithm to determine a priority sequence for repair and distribution actions during a given

time. As mentioned earlier, the DRIVE model contains many but not all of the features required by VISION. Some modifications and extensions will have to be made to DRIVE to meet the needs of the Army VISION Execution System. Here we briefly describe how the DRIVE-like model would work in concept within VISION.

The current DRIVE algorithm begins by assigning a weapon system availability goal to each weapon system "unit" supported by an IDSM organization. This goal is a percentage of fully mission capable weapon systems in terms of the total supported by that IDSM organization. Next, the algorithm computes the number of expected LRU and associated SRU failures at each IDSM organization over the time horizon of interest. In addition to a peacetime horizon, DRIVE uses a short-term wartime operating tempo when computing expected LRU and SRU failures for all units that have wartime taskings. Given this information, DRIVE computes the probability that each IDSM organization can meet wartime and peacetime weapon system availability goals given the current serviceable assets available at the IDSM organizations.

DRIVE attempts to maximize the probability that all supported combat organizations meet their goals as the time horizon ends. It derives priorities for LRU and SRU repair and distribution based on actions that result in the greatest improvement in the objective per resource unit (e.g., dollars or test time) expended on repair and distribution. To be effective in dealing with unforeseen events, DRIVE needs to keep the planning horizon as short as possible and uses up-to-date information on asset status. The improvements in weapon system availability are limited by the availability of carcasses and repair and distribution capacities.

DRIVE has some important features that make the VISION Execution System feasible. First, it uses improvement in probability of meeting weapon system availability goals per resource unit expended as the measure to determine the priority sequence of repair and distribution actions for each LRU and SRU. Second, DRIVE uses indenture relationships to determine the sequence of repairs and distributions. For example, if an IDSM organization has several LRUs that are unserviceable due to a lack of PCBs, DRIVE will determine the most economical mix of PCB repairs and distributions (from the depot) that will maximize the number of LRUs available at that IDSM organization for use in maintaining available weapon systems. Third, DRIVE joins repair and distribution decisions to maximize weapon system availability and provides a mechanism to guide execution actions. Fourth, DRIVE incorporates wartime availability goals into the logic for determining peacetime repair and distribution actions to ensure that peacetime actions will support wartime readiness postures.

Although the current DRIVE model provides a good point of departure for meeting VISION Execution System needs, it does not address all the requirements of the system. The model was designed to assist item managers and depot schedulers in determining necessary depot level repairs and distributions to maximize the probability that each unit supported by an IDSM organization will achieve its weapon system availability goals. The model does not at present address how to coordinate repair and distribution actions when multiple sources of repair exist at the depot level, as is the case in the Army. Nor does the model address how actions at one echelon affect actions at others. For example, if the Mainz repair facility is operable in wartime, what actions should be taken by Sacramento and Anniston Army Depots to complement actions at Mainz? The model does not now answer questions such as when lateral supply and/or repair actions should take place, although a conceptual approach to this problem has been developed. Therefore, DRIVE needs to be to be modified to meet the requirements of VISION.

The Outputs

As Fig. 2.2 shows, the VISION Execution System produces two major categories of outputs that can be used to maximize weapon system availability, given existing resources:

- A sequence of repair actions that allows repair capacity to be expended in a manner that yields the highest weapon system availability payoff.
- A sequence of item distribution to the locations that would result in the greatest improvement in weapon system availability objectives.

Each category is similar for each local module, but the local modules require unique scenario data. The primary difference in the scenario data among the local VISION modules is the time horizon being addressed by the module. As indicated above, for each weapon system "unit," a peacetime operating tempo and short-term wartime operating tempo are added to determine the repairs and distributions needed to fill wartime sustainability requirements. In determining depot repair workloads, for example, a peacetime operating tempo of 30 days and a wartime operating tempo of 30 days may be appropriate. Much shorter intervals may be appropriate for the division or corps applications.

In addition, the system can project longer range forecasts of repair workloads by increasing the time horizon used in generating the forecasts. For instance, quarterly and yearly repair forecasts can be

obtained by increasing the time horizons. These longer range forecasts may be useful in examining resource requirements needed to achieve alternative levels of weapon system availability. For instance, the MSC IM might use this capability to provide insights on the level of repair funding necessary to achieve specific levels of weapon system availability. A DESCOM depot might use the estimates to help determine the number of repair parts needed to fix a given mix of LRUs and SRUs required to meet weapon system availability goals.

Although these longer range forecasts can be used to relate how alternative resource levels affect weapon system availability, they are subject to greater errors than the short-term execution forecasts. As pointed out in the next section, more research is needed to determine how to provide adequate resources, such as spare parts, to allow the repair facility to change workloads to meet unanticipated repair needs in a responsive fashion.

Each of the major output categories should have displays and products tailored to that specific category. Section III describes products associated with each time horizon that may be useful in implementing the system at the MSC/DESCOM level.[5]

THE NEED FOR INFORMATION SYSTEMS TO TIE VISION TOGETHER

If each echelon were to use VISION, the Army would need a network of information systems to supply the scenario and logistics information. In addition, it would need methods of carrying status information about distribution decisions made by higher echelons to lower echelons. To help illustrate these needs, consider Fig. 2.3. This figure shows the organizations that could use VISION, as reflected in Fig. 2.1. Figure 2.3 adds arrows to the earlier figure.

Shown by the vertical arrows on Fig. 2.3, current status information needs to be exchanged among echelons concerning expected distributions, current asset status, flow of reparables, and flow of serviceables.

[5]As an example, repair budget considerations would link the three categories of application at the MSC/DESCOM level. The repair budget development and allocation process could project an annual budget segmented by fiscal quarter for each DESCOM Depot. This quarterly budget could become an input to the quarterly repair planning process, and it provides a dollar constraint for the quarterly computation. The quarterly plan could then prioritize repairs for the quarter and establish budget goals for the quarter. A short-term (bi-weekly) repair execution plan could provide a means of tracking expenditures against the budget goals and scheduling repairs that maximize weapon system readiness given available resources.

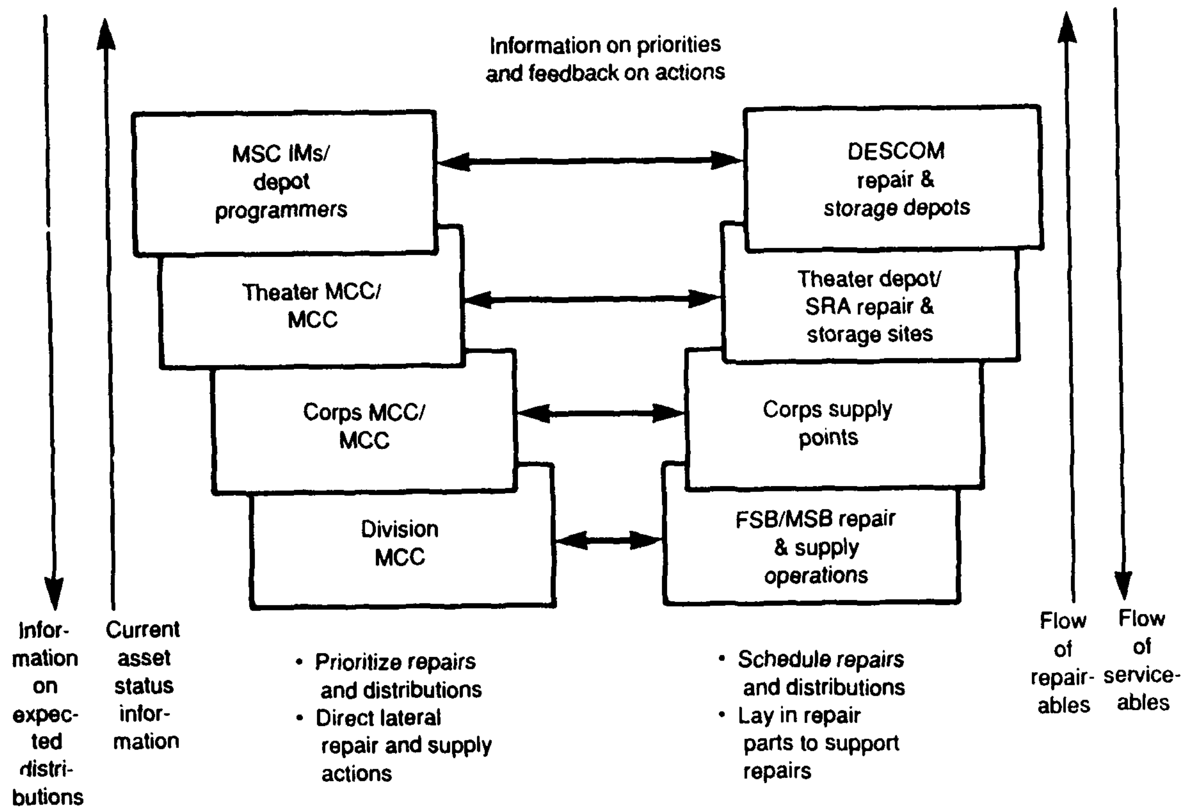

Fig. 2.3—Inter-echelon information needs

The figure does not show all the information flows needed to operate the VISION Execution System. Among the key elements of information absent from Fig. 2.3 are scenario information and more stable asset information. The scenario information, including anticipated weapon system usage rates and availability goals, is assumed to be entered into the VISION system at each echelon by a logistics C^2 system to guide the VISION algorithm in determining repair and distribution priorities. The more stable item-oriented information includes indenture relationships, substitutes and interchangeables, repair times, failure rates, and the like. Mechanisms for storing and updating this information at the local VISION sites need to be developed.

III. A CONCEPT FOR USING THE VISION EXECUTION SYSTEM AT EACH ECHELON

Design of an information system must consider types of input information, the information collection method, the design of the databases, the system modeling and data processing approaches, and the output requirements. Each item can affect the costs and benefits of the system. As a result, it is important to have a good grasp of what a system is intended to do and how it is intended to operate before detailed design work is initiated.

This section outlines one approach for how each echelon could use VISION to coordinate repair and distribution decisions. It is noted that the concept outlined below departs significantly from the way in which these functions are currently directed and controlled. As a result, these ideas raise serious implications not only for the design of future information systems but also for future operating policies and procedures. Other concepts for using VISION should be evaluated in terms of the costs to build the system and its potential effects on projected wartime weapon system availability. If the cost benefit analyses warrant, prototypes of the system should be built to test the ideas and refine detailed design specifications before full-scale development is undertaken. This approach of developing paper concepts, building prototypes, then moving to full-scale development should help refine the system objectives and reduce the risks associated with development.

The remainder of this section describes how the VISION Execution System could be used at various echelons to improve weapon system availability. Since the support structure involved in providing logistic support of major Army weapon systems is tailored to meet the unique requirements of a particular weapon system, the discussion focuses on the M1/M1A1/M2/3 weapon systems.[1]

[1]Translating the system to support other weapon systems is relatively straightforward. The major difference in application would be the designation of the Forward Intermediate Maintenance Organization (IDSM organization). For instance, the FSB is the IDSM organization associated with M1/M1A1/M2/3, whereas the Aviation Intermediate Maintenance (AVIM) squadron is the IDSM organization associated with most aviation weapon systems. In the VISION Execution System, as explained in Sec. III, each IDSM organization must report the status and condition of high-technology spares to echelons above it. Other differences in support of specific weapon systems may involve a difference in the number of support echelons and the capability of repair at each echelon. For instance, the use of Specialized Repair Activities (SRAs) at the corps level for some weapon systems may provide repair normally found at the depot for other weapon systems.

This section first sketches how each of the echelons shown in Fig. 2.1 could use VISION to help integrate repair and distribution workloads to achieve unit level weapon system availability goals. The discussion then turns to several possible VISION displays that decisionmakers at the NICP/DESCOM level could use.

AN INTEGRATED VIEW OF USING VISION AT ALL ECHELONS

To obtain full benefit of support resources, all echelons should act in concert to provide coordinated support to the combat forces. Figure 3.1 illustrates how each echelon could use VISION to provide resources to weapon system units assigned to IDSM organizations, such as FSBs. Each repair and distribution execution decision—at division, corps, theater, and NICP levels—should maximize the probability of meeting specific weapon system availability goals and operating tempo requirements. Given a statement of weapon system availability goals and operating tempo requirements for each unit along with current asset visibility at each echelon, VISION can be used to help coordinate the activities of each echelon. For instance, division MMCs could use VISION to determine the priorities for various LRU repairs and the priorities for distributing repaired LRUs to each of its battalions. The same is true for combat units supported directly by corps IDSM organizations. At higher echelons, the same unit scenario and asset visibility is needed to determine the priorities for SRU repairs so the IDSM organizations can have the right mix of SRUs to fix LRUs needed to maximize weapon system availability.

The VISION Execution System should quickly be able to change repair and distribution workloads when shifts occur in weapon system availability goals or operating tempo requirements. Figure 3.1 shows how VISION could automatically accept these shifts from a C^2 system designed to communicate weapon system oriented goals to the logistics execution systems. The system should also be able to respond to special actions, such as losses of stocks caused by attack. In these cases, VISION may reroute stocks from one unit to another, or it may route depot shipments to units that incur damages.

In peacetime, the Army primarily uses a three-echelon concept of repair for high-technology systems. In general, organizational maintenance units replace faulty LRUs in the weapon system. These units use specialized test equipment to identify faulty LRUs, which in turn are repaired at IDSM organizations by replacing faulty SRUs with serviceable ones. These organizations use specialized test equipment to

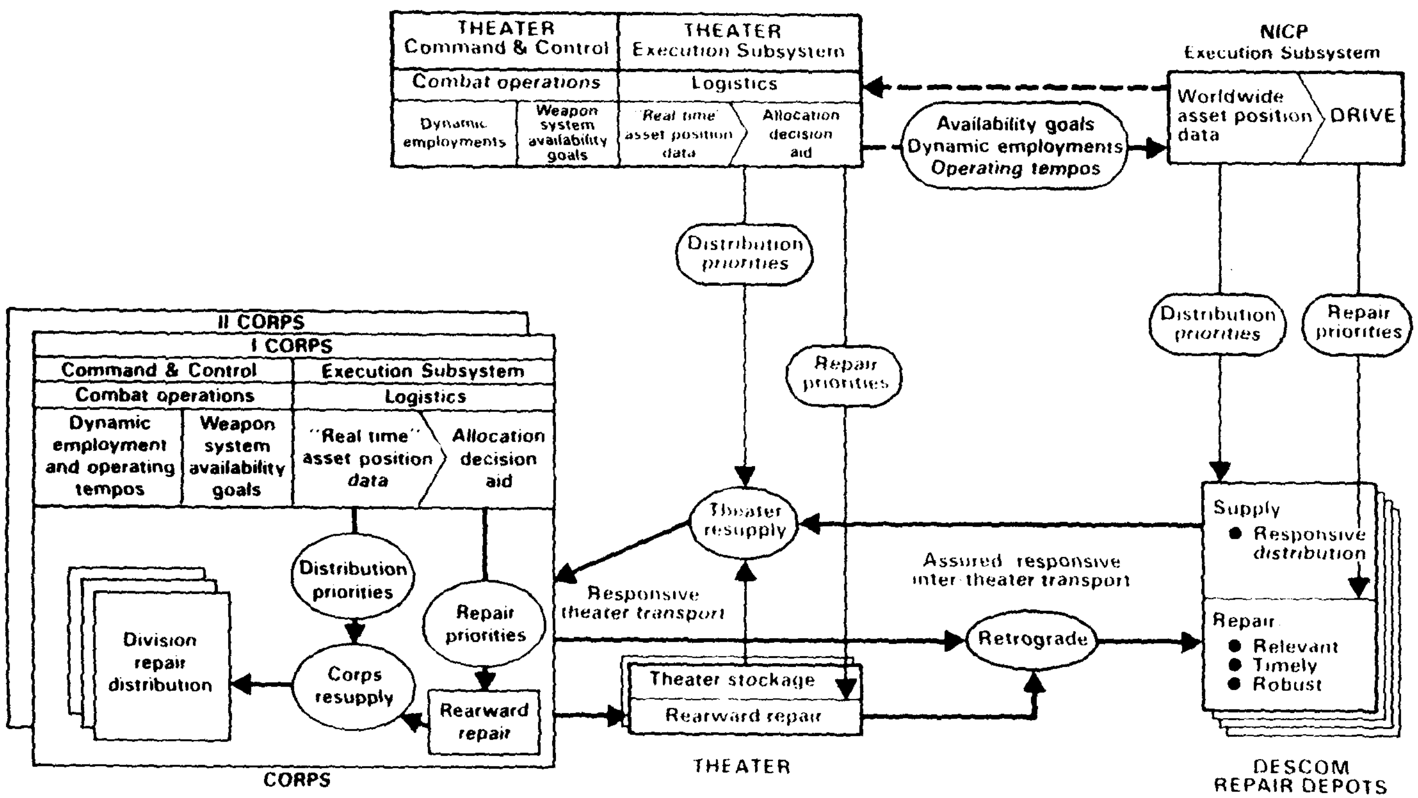

Fig. 3.1—Integrated logistics execution system

identify faulty SRUs, which in turn are evacuated to a designated depot level Source of Repair (SOR). The SOR for the SRU then uses specialized test equipment to isolate the fault on the SRU and replaces the failed component.

As an example, in peacetime situations failed SRUs for M1 units in Europe are sent from each FSB to the theater repair facility at Mainz for repair. For M1 units in the CONUS, SRUs are repaired either at Anniston or Sacramento Army Depot depending on the particular SRU. The corps level is by-passed and support is provided directly to the FSB/MSB by the depot level facility. In this case, VISION could be applied at the division level and depot level to meet most uncertainties associated with peacetime environments.

In wartime situations, however, the primary SOR for SRUs may be damaged, especially if the SOR is in the theater. In addition, division priorities can change rapidly. That is why Fig. 3.1 shows VISION connections between the theater and CONUS NICPs/depots. Should the SRU repair facility in the theater be damaged, the IMs would need to have the same information as the theater MMCs to schedule workloads to support the overflow requirements that may occur in wartime.

THE USE OF VISION AT DIVISION/CORPS/ THEATER LEVELS

This subsection discusses in more detail one view of how field units could use VISION, as well as some alternative views.

Use at Division

Because of the data collection and processing necessary to execute VISION, the lowest level at which it would be installed would probably be at the division MMC. At this level, the DMMC could run VISION to help determine repair priorities for each of the FSBs and distribution from the MSB ASL to each of the FSBs. VISION could also identify the benefits of reallocating serviceables arriving at the MSB from higher echelons which may have been destined for one FSB to another. The DMMC could use VISION for determining when lateral supply or repair actions among the FSBs should take place. In this case, a "reluctance function" would need to be developed to help MMC personnel determine when they should undertake a lateral repair or resupply action. This function would develop a ratio of weapon system availability improvement per cost of transporting and repairing an asset for lateral repair. When an appropriately determined value of the

ratio is exceeded, a derivative of DRIVE could recommend lateral support actions.

If one were using the VISION system to determine peacetime repair priorities for a set of FSBs, the peacetime and wartime planning horizons would be much shorter than those used at higher echelons. For example, the FSBs could be expected to meet demands in one or two days. Thus, the look-ahead time horizon at this level needs to be as short as possible to react to changing circumstances. Perhaps three days of peacetime operating tempos and 15 days of wartime operating tempos expected to be met by those units could be used to make execution decisions.

Longer time horizons could be used to help determine how many SRUs may be necessary to have on-hand to meet expected short-term LRU workloads. These longer-term estimates would be subject to forecast errors, as discussed earlier, but would provide insights on spares needed to achieve projected weapon system availability targets.

Use at Corps

As shown in Fig. 3.2, unit level weapon system availability goals. operating tempo, and asset positions could be supplied to DRIVE at the corps MMC to make repair and distribution decisions for the division MSBs for eventual distribution to the FSBs. In the cases where a corps may control the activities of a Specialized Repair Activity, the system could direct and control the SRA repair and distribution priorities to achieve unit level weapon system priorities.

The corps could also play an important role in reallocating serviceable assets arriving from higher echelons at the divisions (MSBs). In this concept, the corps rather than the theater MMC would attempt to reallocate incoming shipments from the CONUS. This procedure would reduce the decision points involved in the reallocation of intransit assets. The corps could also be involved with reallocation of assets among the MSBs and FSBs to achieve specific unit level weapon system availability goals.

Use at the Theater

As shown in Fig. 3.2, the same unit level information is supplied to the theater MMC to assist in developing repair and distribution priorities as it is to the corps level. Where the theater MMC controls the actions of in-theater depots, the activities would be very similar to those of the NICP described in the next section. The theater MMC could also help reallocate assets among corps to meet weapon system availability goals of specific units.

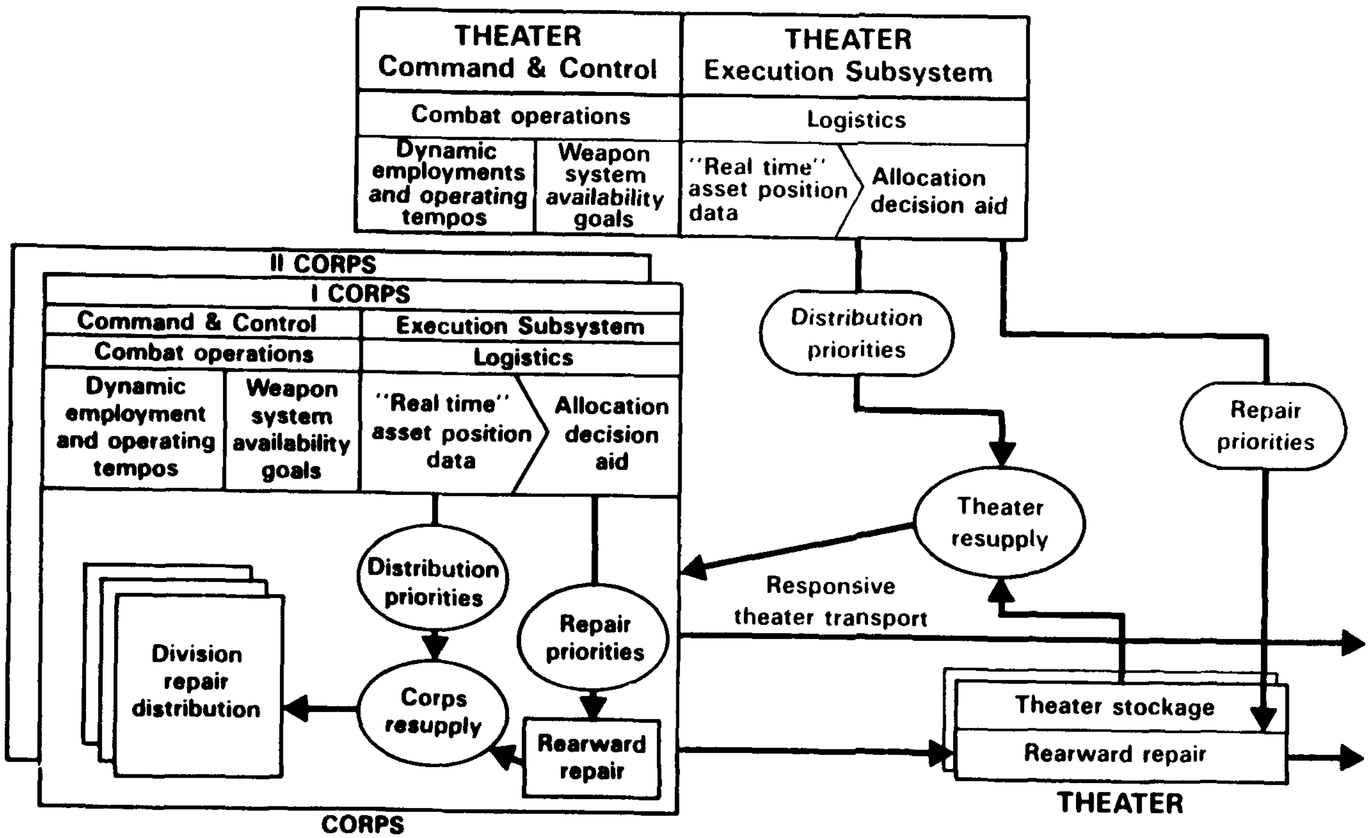

Fig. 3.2—Field level view of integrated execution system

THE USE OF VISION AT THE MSC/DESCOM LEVEL

The VISION Execution System could assist with three important functions that affect depot repair effectiveness and efficiency:

- Scheduling and execution activities
- Workload activities
- Annual planning activities.

In each case, we present the potential output products and their value as decisionmaking tools.

Although the discussion, tables, and figures that follow are primarily oriented toward repair decisions, VISION also can help distribute assets. The same logic underlies both the repair priority problem and the distribution problem: to achieve weapon system availability goals, we must use the most current, near-real-time data available.

Scheduling and Execution Activities

This subsection explains how a short-term (e.g., bi-weekly) VISION execution process can enhance current procedures for scheduling and program execution at the MSC/DESCOM level by clarifying priorities. facilitating rapid responses to changing circumstances, and bringing a weapon system orientation to the system.

The current process of scheduling depot workload reflects both the priorities established by the IMs and the desire of depot management to maximize the efficiency of workforce and resource utilization. IM priorities are specified as Issue Priority Designators (IPDs) ranging from IPD 01 (most urgent) to IPD 15 (least urgent) as set forth in UMMIPS. The Standard Depot System (SDS) has a built-in scheduling algorithm that designs production schedules based on equipment availability and item priority. This set of procedures is not usually used on an exclusive basis, but instead provides a framework for the production controller and shop foreman to use in constructing a final schedule.

Depot schedules cover a period of one month, and tend to be unspecific. Typically, they indicate items to be repaired and they give a quantity for each; they do not specify the order to be followed. This decision falls primarily to the shop foreman, who is allowed to pursue efficiency goals. In most activities, this results in heavy batching of repairs (i.e., working on many units of one type of item in sequence, and then moving on to another type of item).

Several factors affect the manner in which depot maintenance programs are executed. Perhaps the most significant is the status of

repair parts stockage. Whether because of unanticipated demands or the unavailability of long-lead-time items, repair parts are a leading cause of program delays. Also contributing to program delays is the lack of unserviceable assets. As a rule, PWDs are not written unless enough unserviceables are on-hand or on the way to the depot. If returns fail to meet expectations, PNs may be forced off schedule. Whatever the cause, the depot does not have the authority to deviate from a PN without the approval of the responsible IM. Formal quarterly reviews allow depot production controllers to review program status with IMs and depot programmers. In addition, intensively managed items are reviewed on a monthly basis, with constant informal contacts in the intervening periods.

PNs are also subject to increase as circumstances dictate. If worldwide demands rise unexpectedly or if local shortages appear at field installations, the IM can increase production. He asks the depot programmer to submit a revised PWD to DESCOM and then to the depot. He can also alter the IPD value on an existing PN, thereby causing that item to advance within the repair process.

The application of the VISION Execution System would change this process in several significant ways. First, the forecast period would be shortened to deal with uncertainty. At this echelon, a short-term (e.g., bi-weekly) repair projection produced by VISION and based on current force postures and asset positions would lessen the forecast errors by shortening the forecast time horizon. The shorter update period would also allow the depot level system to be more responsive to meeting the needs of the combat forces.

Perhaps the most noticeable effect of using VISION in a bi-weekly execution mode is that it eliminates any need to indicate repair priorities. Rather than relying upon the subjective assessments of many different IMs, VISION prioritizes in a uniform fashion with a single, consistent objective function—maximizing the likelihood of achieving weapon system availability goals. It assigns no quantitative priorities to items, but instead generates an ordered list that ranks items according to their contribution to the objective function. Rather than being limited to 15 classes (which may be inconclusive when dealing with hundreds of different items), VISION establishes a clear precedence relationship for every item.

Because of its objective function of maximizing the probability of meeting weapon system availability goals, VISION will probably deviate from the common technique of batching similar items into large production runs. In fact, it may suggest the diametrically opposite approach of alternating from one type of item to another with each repair completion. If this seems overly capricious, it needs to be emphasized that the VISION list need not be taken too literally; it

should guide intelligent, responsive decisionmaking. In the present instance, a compromise of modest batch sizes would probably serve the objective function without unduly disrupting smooth shop operations.

In addition, VISION rapidly compensates for fluctuations in requirements in this setting. Now, the IM must reissue the PWD with all the attendant processing by the depot programmer, DESCOM, and the depot. But VISION—with its links to current asset reporting systems—could automatically adjust in its next bi-weekly computation. It would meet increased demands for a particular item by advancing unserviceable assets of that type in the VISION list. Similarly, it would compensate for decreased demands by moving items to the bottom of the list. Furthermore, VISION would not confine this responsive behavior merely to the subset of intensively managed items—it would extend to all items in the VISION database.

In its bi-weekly execution mode, VISION could produce a prioritized repair list like the one shown in Table 3.1 for items repaired on the EQUATE test station at Sacramento Army Depot. The columns in the list are defined below:

Rank	Priority ranking in the list. The higher an item's rank, the greater its contribution to the objective function.
NSN	The item's National Stock Number.
Nomenclature	The item's name.
CUM Rep	A cumulative count of the number of items of this type that have already appeared on the list.
Std Hrs	Standard repair time in man-hours (or machine-hours).
CUM Hrs	Sum of standard repair times for all items that have already appeared on the list.

If the EQUATE test station performed repairs strictly according to this list, it would maximize the VISION objective function after every completion. Observe, however, that it would probably make sense to batch items 1, 3, 5, and 7 because they are so closely grouped within the list that the convenience of repairing them in sequence would more than compensate for the minor deviation. On the other hand, it may be incorrect from the standpoint of weapon system availability to include item 27 in that same batch because of the resulting delay to the intervening entries in the list.

Table 3.1

BI-WEEKLY REPAIR LIST

Rank	NSN	Nomenclature	CUM Rep	Std Hrs	CUM Hrs
1	1430-01-126-3340	Error Preamplifier	1	5.5	5.5
2	1240-01-118-3937	AC Generator	1	9.3	14.8
3	1430-01-126-3340	Error Preamplifier	2	5.5	20.3
4	1005-01-110-5394	Super Elevation	1	4.3	24.6
5	1430-01-126-3340	Error Preamplifier	3	5.5	30.1
6	1240-01-116-4545	Linear Regulator #2	1	10.1	40.2
7	1430-01-126-3340	Error Preamplifier	4	5.5	45.7
8	1240-01-197-1758	Error Detector	1	27.3	73.0
9	1005-01-110-5595	Mirror Servo	1	31.9	104.9
10	1005-01-110-5394	Super Elevation	2	4.3	109.2
11	1005-01-110-5595	Mirror Servo	2	31.9	141.1
12	6110-01-115-9106	Switching Preregulator	1	4.1	145.2
13	1005-01-110-5394	Super Elevation	3	4.3	149.5
14	1240-01-116-4545	Linear Regulator #2	2	10.1	159.6
15	1240-01-116-4545	Linear Regulator #2	3	10.1	169.7
16	1240-01-118-3937	AC Generator	2	9.3	179.0
17	6110-01-115-9106	Switching Preregulator	2	4.1	183.1
18	1240-01-116-4545	Linear Regulator #2	4	10.1	193.2
19	1005-01-110-5595	Mirror Servo	3	31.9	225.1
20	6110-01-115-9106	Switching Preregulator	3	4.1	229.2
21	1005-01-110-5595	Mirror Servo	4	31.9	261.1
22	6110-01-115-9106	Switching Preregulator	4	4.1	265.21
23	1240-01-116-4545	Linear Regulator #2	5	10.1	275.3
24	6110-01-115-9106	Switching Preregulator	5	4.1	279.4
25	1005-01-110-5394	Super Elevation	4	4.3	283.7
26	1240-01-197-1758	Error Detector	2	27.3	311.0
27	1430-01-126-3340	Error Preamplifier	5	5.5	316.5
28	1005-01-110-5394	Super Elevation	5	4.3	320.8
29	1240-01-118-3937	AC Generator	3	9.3	330.1
30	1240-01-116-4545	Linear Regulator #2	6	10.1	340.2

The cumulative hours helps gauge the productive capacity of the work center. If, for example, a total of 200 hours of test time are available during the two-week period, we could draw a line beneath item 18 and establish the completion of the first 18 items as the production goal for the period. This is entirely analogous to the current goal of completing a monthly quota. Of course, VISION produces considerably greater flexibility; if any of the first 18 items cannot be repaired, priorities for substitutions are already clearly defined and need not be computed as exceptions.

Workload Activities

We next discuss the application of VISION in workload planning activities at the MSC/DESCOM level. The primary reason to use VISION for this purpose is to forecast repair workloads over an intermediate time period, such as a quarter.

A quarterly VISION run can anticipate the directions that subsequent bi-weekly computations will take. It can forecast production quantities over a quarter and possibly influence IM and depot programmer decisions about which PWDs are most important in terms of funding precedence. The value of this capability increases as budgets become more constrained with respect to requirements.

In addition, forecasts of production quantities will help provide repair parts in a timely manner. Because VISION offers a better hedge against uncertain futures (by generating a repair list that extends well beyond a shop's capacity constraints), it provides an opportunity to plan for contingencies when requisitioning repair parts.

Since quarterly VISION runs are simply extended versions of short-term (e.g., bi-weekly) execution runs, they need extended scenario data (a longer time horizon, for example). The other types of data remain the same as those described in the preceding subsection.

Table 3.2 shows a sample VISION report that summarizes forecasted quarterly production for the set of EQUATE items considered above. A derivative of DRIVE has been run for a quarter with five levels of EQUATE capacity. For each level, VISION forecasts the number of items that should be repaired. This report can help evaluate the potential

Table 3.2

QUARTERLY REPAIR FORECAST FOR VARIOUS CAPACITY CONSTRAINTS

		Available Repair Hours				
NSN	Nomenclature	440	880	1320	1800	2640
1430-01-126-3340	Error Preamplifier	12	23	25	30	36
1240-01-118-3937	AC Generator	3	8	14	21	32
1005-01-110-5394	Super Elevation	6	10	12	13	16
1240-01-116-4545	Linear Regulator #2	9	13	16	18	24
1240-01-197-1758	Error Detector	3	8	15	24	34
1005-01-110-5595	Mirror Servo	4	8	10	12	20
6110-01-115-9106	Switching Preregulator	5	8	27	40	65

contributions of such factors as an additional test station, an added work shift, or the assignment of workload to an external contractor.

Annual Planning Activities

VISION could serve as an annual planning tool at the MSC/DESCOM level. In this application, the scenario information would cover 12 months of expected peacetime operating tempo for each weapon system plus the appropriate additional wartime operating tempos for units assigned combat roles. Outputs from the runs could provide aggregated lists of repairs and resulting costs necessary to achieve alternative levels of weapon system availability. In addition to helping define the repair funding necessary to achieve specific weapon system availability objectives, the estimates could help determine repair parts requirements over a long time horizon. If the lead times for repair parts to fix LRUs/SRUs are long, it may help justify expenditures on long-lead-time items.

Although subject to great uncertainty, these long-range estimates relate how alternative resource levels affect weapon system availability. In addition, several sensitivity analyses could be run using different parameter values to determine appropriate funding for the repair and purchase of parts. Once a target has been established, the quarterly updates can help make mid-term corrections. The bi-weekly runs will continue to help the depot respond to the force in an effective manner, while the longer term analyses will help the depot determine longer range resource requirements.

Table 3.3 provides an example of an output product that may prove useful in annual repair planning. It also shows the expected number of repairs for a group of items in the next four quarters. This information could assist in determing how to provision repair throughout the year.

Table 3.3

ANNUAL REPAIR FORECAST BY QUARTER

		Quarter				
NSN	Nomenclature	1	2	3	4	Total
1430-01-126-3340	Error Preamplifier	12	11	2	10	35
1240-01-118-3937	AC Generator	3	5	6	4	18
1005-01-110-5394	Super Elevation	6	4	2	7	19
1240-01-116-4545	Linear Regulator #2	9	4	3	2	18
1240-01-197-1758	Error Detector	3	5	7	10	25
1005-01-110-5595	Mirror Servo	4	4	2	6	16
6110-01-115-9106	Switching Preregulator	5	3	19	9	36

IV. POTENTIAL BENEFITS AND COSTS OF THE VISION EXECUTION SYSTEM

Before serious consideration is given to a system like VISION—which differs so greatly from current support concepts—the benefits and costs of such a system must be estimated. The benefits include improvements in how components of the total support process, including logistics management systems (LMS), affect wartime combat capability.

A stream of RAND research has shown that alternative support concepts that couple responsive repair and distribution capabilities with a VISION-like management system can significantly improve weapon system support. The results of one of these studies—a study that addresses alternative support concepts for the M1—are used here to provide insights on the potential worth of an execution system with VISION characteristics.[1]

THE ANALYSIS METHODOLOGY

To assess the impacts of support concepts incorporating the use of a VISION-like execution system with rapid repair and distribution capabilities, the M1 Alternative Structures Study used RAND's Dyna-METRIC model. A dynamic model of the component support process, Dyna-METRIC produces combat-relevant output measures such as available weapon systems as a function of logistics inputs. The Air Force has used it extensively to conduct sustainability assessments.[2]

An Army derivative of Dyna-METRIC uses analytic techniques that capture the operating tempo of a combat unit or set of units in sufficient detail to estimate how important aspects of the component spares support process—such as available assets, repair capability, and

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[1]See Berman et al., October 1988.

[2]Dyna-METRIC is embedded in the Air Force Weapon System Management Information System (WSMIS). WSMIS provides weekly assessments to Air Force wing commanders and is reported in the Air Force Unit Readiness Reporting System. For more information on WSMIS, see *WSMIS Sustainability Assessment Module (SAM), Functional Description (Version 8.0)*, Dynamics Research Corporation, Andover, MA. For more information on Dyna-METRIC, see R. J. Hillstad, *Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control*, The RAND Corporation, R-2785-AF, March 1982; K. E. Isaacson, P. M. Boren, C. L. Tsai, and R. A. Pyles, *Dyna-METRIC Version 4: Modeling Worldwide Logistics Support of Aircraft Components*, The RAND Corporation, R-3389-AF, May 1988.

transportation capability—will affect weapon system availability or weapon system operating hour generation capability. Dyna-METRIC can examine several "what if" questions. Among its variable input parameters are scenarios for weapon system employment and deployment, component reliabilities, repair capability, repair strategies (selective replacement, priority repair), transportation capability, and stock levels. Because Dyna-METRIC forecasts the effects of these factors on weapon system availability, it shows the consequences of using alternative resource mixes or policies, including VISION's repair priority decision system. Because it incorporates wartime dynamic changes in operating tempo, employment tactics, attrition rates, and support capability, it facilitates the analysis of complete wartime phased deployment plans.[3]

The Evaluation Case

Scenario. The M1 Alternative Structures Study examined the supportability of one corps of M1s employed in a scenario like that in the P90E Concepts Analysis Agency's Concepts Evaluation Model of a Central European war. The analysis includes all M1 tanks owned by the division, but excludes those owned by the cavalry regiment or independent brigades.

The evaluation looked at the daily tank activity of a total of 928 M1 tanks in three divisions, one armor and two mechanized. The armor division consists of six armor battalions, with 58 tanks each; the mechanized divisions consist of five 58-tank battalions each. For each brigade (or fraction of a brigade) for each day, the evaluation used a 120-day scenario with force postures that include offense, intense defense, and light defense static. For each posture, an armor center model provides average per tank combat hours ranging from 7.7 hours per day for light defense/static to 15.1 hours per day for full offense. For each day of combat, the brigade is assigned a tank hour activity level that applies to all tanks available in the brigade on that day.

[3]The model requires fairly detailed data to conduct readiness and sustainability assessments of logistics support alternatives. The major inputs are similar to those required by DRIVE and consist of weapon system operating requirements, logistics performance factors, asset availability, and indicative item-oriented data. For instance, the model needs to know the components on the weapon system, the components' removal rates, and depot and forward echelon's repair capability for each item of interest. Further, it needs the relevant operational deployment and employment plan, including the number of weapons involved in the scenario and the operating tempo per day. Finally, it needs information on how support resources and capabilities vary over time, including when CONUS depot repair becomes available and when CONUS resupply becomes available.

The Logistics Support Structure. The logistics structure of this three-division "corps" is standard Army form, with each brigade having an FSB and each division having an MSB (see Fig. 4.1). In turn, the three divisions are linked to a CONUS depot (although a theater-level repair facility may be used). The evaluation does not model in detail repair forward of the FSB.

Components Evaluated. The analysis includes those M1 components that reflect the greatest change in tank technology, cost, and complexity. Of the total of 205 LRUs on the M1, 19 LRUs in the M1's fire control and stabilization system and 11 LRUs in its engine system are evaluated (see Table 4.1). All the LRUs either use or are embedded in relatively complex electronics technology. Although the LRUs constitute but 15 percent of the tank's components, they account for 56 percent of all its maintenance actions. In addition, the LRUs add the most value to tank performance. For example, tanks without their laser rangefinders operate with but 63 to 66 percent of their previous combat effectiveness.[4] In addition to these items, the analysis included

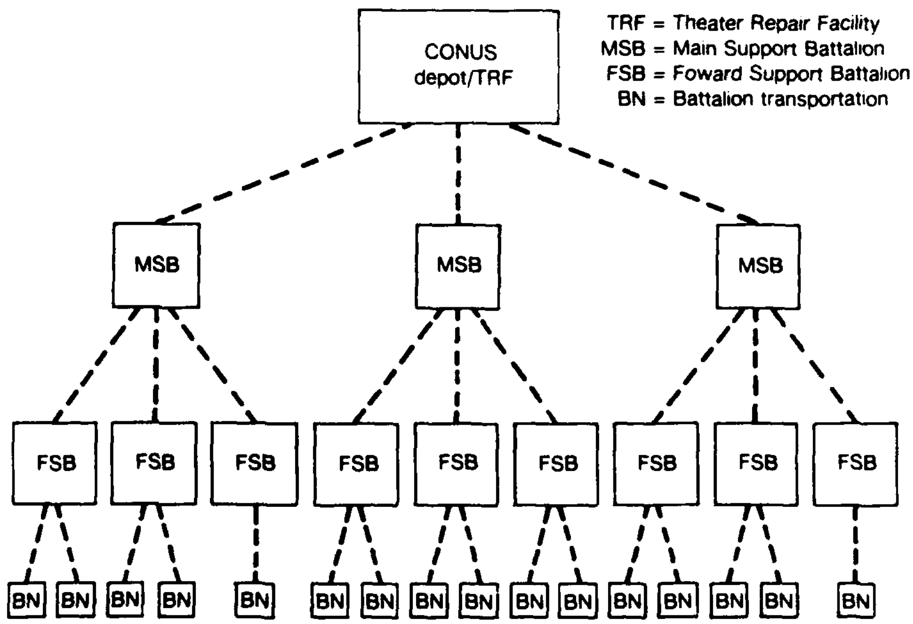


Fig. 4.1—Logistics structure used in scenario

[4]Personal communication from Walter Clifford, Division Chief, Air Warfare Division, Army Materiel Systems Analysis Activity.

Table 4.1

HIGH-TECHNOLOGY LRUs IN THE M1 TANK

LRUs in the Fire Control and Stabilization System	LRUs in the Engine System
Turret Networks Box	Turbine Engine
Crosswind Sensor	Fuel Nozzle
Computer	Electrical Fuel Pump
TIS Power Control Unit	Electronic Control
Gunner Body Assembly	Electro-Mech-Fuel
TIS Image Control Unit	Fuel Control
TIS Thermal Receiver	Distribution Manifold
Laser Rangefinder	Forward Engine Module
Turret Drive	Rear Engine Module
TIS Electronic Unit	Combustion Liner
Servomechanism Assembly	Accessory Gearbox
Servomechanism Traverse	
LOS Electronic Assembly	
Slip Ring Assembly	
Panel Assembly	
Gyro Assembly Rate	
Head Assembly	
Computer Control Panel	

SOURCE: Berman et al., October 1988, Table 2.1.

such facts as that LRU removals for the sample of items accounted for over 70 percent of all M1 LRU removals.

Parameters. The evaluation used data from the Army's Sample Data Collection (SDC) system to estimate the rate of removal, test equipment use and repair time, SRU use rate, and indenture relationships of systems, LRUs, and SRUs.

Data on war reserve stock requirements for theater and wholesale came from the Tank and Automotive Command (TACOM) and the Armament, Munitions, and Chemical Command (AMCCOM). The evaluation assumed that the MSB had theater reserve LRU stock, and that each division's ASL was located at the FSB.[5]

The evaluation also assumed that the M1 workload would be supported by one half of the 18 Direct Support Electrical System Test Sets and Thermal System Test Sets available to the corps to support both the Bradley Fighting Vehicle and M1 tanks. Located at the MSB, the test equipment had an estimated availability of 70 percent.

[5]The ALS was derived from a recent Support List Allowance Computation (SLAC) computation from Army Materiel Command Headquarters.

The Logistics Intelligence File (LIF) provided transportation information for the M1. Reviewed with other LIF data and with the Uniform Materiel Movement and Issue Priority System (UMMIPS) standards, these data suggested nominal estimates of 21 days order-and-ship time for serviceables and 28 days *retrograde time for reparables*.

Strategic and tactical transportation will be overloaded in any major European contingency. The evaluation assumed a 30-day cutoff of repair parts, supply, and retrograde to CONUS depots because most inter- and intra-theater transportation would be involved with unit movement during this period.[6] For alternatives using assured transportation, a 10-day cutoff was examined because of inevitable lags in establishing support systems in the midst of a major deployment.

THE RESULTS OF THE ANALYSIS

The evaluation used the *current system* as a base case, with tanks supported by nine sets of test equipment and spares at the brigades' FSBs. The base case assumed that the division's ASL is at the FSBs, the theater war reserve materiel is available at the MSB, and the wholesale war reserve materiel is in the depot. In addition, each battalion is supported by the current distribution system. For the base case, Dyna-METRIC found that at day 30 of the war scenario 50 percent of the tanks were not available because of lack of serviceable components.

As comparisons to the base case, several simulations were run of responsive repair and distribution systems of the kind that VISION could help provide. The repair and distribution systems options differ in the degree of responsiveness and the level at which they use the capabilities of a VISION system.

The first option examined the weapon system availability and cost effects of using responsive repair and distribution capabilities and a VISION-like system *at the division level*. In this analysis, it was assumed that the division had visibility of the assets and needs of the division's combat forces and that it used this information to conduct repairs and distribute assets to maximize weapon system availability. This option also reduced the order and shipping time and retrograde time between the division and the supporting CONUS or in-theater

[6]See Michael D. Rich, W. L. Stanley, and S. Anderson, *Improving U.S. Air Force Readiness and Sustainability*, The RAND Corporation, R-3113/1-AF, April 1984. Besides reflecting the heavy loading of transportation in the early deployment period, this 30-day cutoff is used in the wholesale war reserve computation.

depot to seven days each way. The option also assumed the depot would repair critical items within a ten-day time frame.

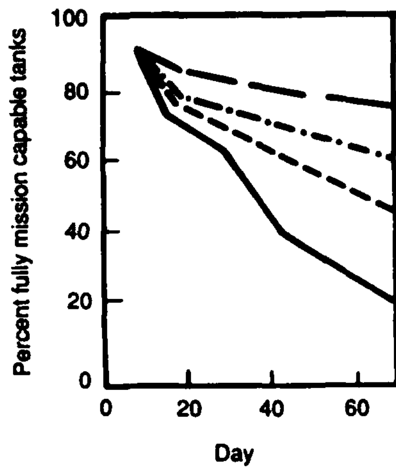
A second option examined the effects of using a VISION-like system *at both the corps and division levels.* This option uses the same assumptions found in the first option. The main difference is that the corps has the visibility to reallocate resources from one division to another to maximize weapon system availability.

A third option examined the effects of using a VISION-like system *at all echelons* including the NICP/depot level. It reduced the transportation time to and from the divisions and the depot facility to two days, and it used a three-day repair time for a total of seven days for the depot repair cycle.

Figure 4.2 compares the results of the analyses of the current (base case) system and the hypothetically responsive repair and distribution systems that could be achieved with the help of a VISION Execution System. The solid line shows the expected fully mission capable (FMC) percentage for a corps of M1 tanks, given authorized assets and current repair policies. The short dashed line shows the benefits of using the VISION Execution System and responsive repair and distribution at the division level. The dotted line shows the benefits of using this responsive system at division and corp levels. The long dashed line shows the benefits of using VISION at all echelons coupled with responsive distribution.[7] At day 30 of the war, about 80 percent of the tanks are FMC with the optimistic total VISION system with substantial improvements indicated with applications at lower levels. The use of VISION coupled with responsive repair and distribution could improve the availability of M1s by 30 percent over the current system on day 30, or over 300 tanks in this limited scenario.

The evaluation can also be used to provide insights as to the upper bound one may be willing to pay for a VISION system to support a corps of M1s. The study estimated the additional costs of responsive transportation and distribution and then used Dyna-METRIC to determine the amount of additional stock that would have to be purchased to provide the same weapon system availabilities as the responsive repair and distribution options (see the right column of Fig. 4.2). For instance, the costs of additional stocks necessary to achieve equivalent performance of a responsive system at all levels was estimated to be over $230 million for one corps of M1s in this scenario through 120

[7]The analysis only approximates the benefits of adopting a VISION priority system. In essence, each item repaired at the depot received the benefit of lower processing times. In addition, the version of Dyna-METRIC used in these evaluations used priority repair of the IDSM organization, but distributed serviceable assets to the final user within a standard transportation time from the IDSM site.



	Additional costs ($ millions)	
	Responsive repair and distribution *alternative*	Stock buy out alternative
Optimistic total system	$50	$232
Responsive repair and distribution within corps	$12	$102
Responsive repair and distribution within divisions	$11	$ 57
Baseline system	0	0

Fig. 4.2—Approximate costs and benefits of a responsive execution system

days of the war scenario. The responsive systems that would provide more rapid transportation and repair would cost an additional $50 million, some $182 million less than the stockage cost.[8] These additional stockage costs are shown on the right side of Fig. 4.2. However, the additional costs for the responsive systems were estimated to be lower than the additional stockage costs to achieve the same weapon system availability, as shown in the left column of Fig. 4.2.

In sum, Berman et al. estimated that the additional costs to operate a responsive logistics system with VISION-like capabilities was less than 25 percent of the cost associated with an attempted "buy out" of stocks needed to achieve the same weapon system availability objective using the current execution systems. In the limited scenario studied in Berman et al., this difference would mean that the value of such a system (savings over the "buy out" solution) for M1 support alone would approach $180 million for each corps. Extrapolating this cost advantage across all M1 corps and extending its use to several weapon systems indicates that the development of such an execution system could be extremely cost effective. The costs to build and operate a system like VISION have not been included in the costs. However, the study does provide insights on the upper bound of the worth of such a system. For instance, the cost of building VISION could cost up to $180 million, before the buy out solution is cost effective for one corps of M1s.

Even if the Army could afford this buy out expense, it would still be an imprudent investment because the price of this strategy depends on the specific variability measures used to estimate the buy out price. As mentioned above, the variability in demand constantly changes and thus could lead to the wrong mix of stocks being purchased to cover the variability. In addition, the M1 buy out did not consider the stocks needed to cover the variability associated with wartime damage to the support structure resulting from enemy actions. In sum, the buy out strategy is an unsatisfactory solution for dealing with uncertainty.

The development of a VISION Execution System provides a needed capability to deal with uncertainty. Repair and distribution are much more flexible than stockage. If managed properly, they can mitigate the effects of uncertain demands. For instance, if there are shortages of serviceable components at some locations, responsive repair and distribution actions can move unserviceable carcasses to a repair facility

[8]A portion of the associated costs was spent to increase the number of test stands from nine to 16 to accommodate faster repair. With an LMS like VISION, which could prioritize workload to achieve maximum benefit of existing test stands, it is debatable whether this investment would be necessary. To be conservative in estimating costs, it was left in the costs of adding VISION.

with the required repair equipment and technicians. They can move serviceable assets to the units that need them most, and they can fix the carcasses in the order that maximizes combat capability.

In short, adopting a logistics decision support system such as VISION, which promotes responsive repair and distribution actions, appears to have significant payoffs in terms of improving weapon system availability and provides the basis for dealing with uncertainty in a flexible fashion. When summed across all weapon systems that VISION could support, the gains seem impressive.

V. IMPLEMENTATION ISSUES

Before VISION can be implemented at each echelon as outlined above, several key issues must be resolved:

- The range of items for which a VISION-like system is appropriate
- The purchase of repair stocks to facilitate responsive repair
- The coordination of workloads
- Implications for information systems
- Larger issues involving workload planning.

Each of these issues needs further research. Solutions to all need not be found before implementation, but a series of evolutionary prototypes should be developed and tested to help resolve these issues while incremental development of the system proceeds, providing that the benefits warrant the use of tested portions.

THE RANGE OF ITEMS

A VISION-like system should be appropriate for the many spare parts that will be subject to the uncertainties described earlier in this report. It may also be appropriate for other resources, like munitions or POL, which are necessary to conduct combat operations. VISION is a relatively sophisticated decision support system that relies upon obtaining fairly detailed and accurate scenario and logistics information. The collection of this information is expensive. As shown in Sec. IV, use of a VISION system for mission essential high-technology high-demand items could significantly increase weapon system availability for reasonable investments. In some cases, the cost of using the system may be more expensive than "buying out" enough resources to absorb the effects of unexpected demands. In other cases, a more streamlined version of VISION may be appropriate. Detailed research must be conducted to determine the resource characteristics of good candidates for inclusion in a VISION system.

The potential advantages of using a repair prioritizing scheme depend on the scope of repair in a shop. If a repair resource can accommodate many items, tradeoffs can occur across items in terms of their importance to the force. As an example, the scope of repair at FSBs and depot installations associated with M1 electronic systems is

large, and choices have to be made about the priority of repairs that cross a given test station.

At the depot level, for example, most SRUs or PCBs associated with the M1 fire control system are repaired using EQUATE test stands at Anniston Army Depot, Sacramento Army Depot, and the Mainz Repair Facility in Europe. At the FSB level, LRUs associated with the M1 fire control system are repaired using the Direct Support Electrical Systems Test Set. Today's Army information systems do not show current-unit and near-term anticipated needs. As a consequence, IMs and MMCs cannot relate repair priorities to weapon system availability.[1]

As an example of how VISION could enhance depot repair and distribution decisions, consider the EQUATE M1, M1A1, M2/3, and common module workload at Sacramento Army Depot. This shop repairs 24 different PCBs. VISION could determine the sequencing of PCB workload on the EQUATE to maximize the availability of weapon systems using the PCBs. Changing the workload on the EQUATE involves the relatively easy task of changing the testing software (Test Program Set—TPS) and adaptors related to the specific PCB being tested. Once repairs were completed, VISION could indicate where to distribute serviceable assets to maximize weapon system availability. Thus, the potential advantages for using VISION in a shop like this are large because the scope of repair and distribution decisions is broad.

The application of VISION to facilitate distribution has great potential. IMs and MMCs must choose where to distribute limited assets during peacetime and wartime. The VISION Execution System should be useful in both environments.

PURCHASE OF REPAIR STOCKS

As described earlier, repair can mitigate the effects of unexpected demands for high-technology spare parts. VISION has been designed to adjust repair priorities in a responsive fashion to keep pace with combat unit needs. To respond to changing repair needs, repair facilities need to be able to obtain the repair parts needed to fix LRUs and SRUs. A number of strategies could ensure the availability of required repair stocks to meet unpredictable LRU and SRU workloads. One

[1]The IMs at a NICP negotiate individual item repair programs with depot programmers at the National Maintenance Point (NMP) to lay out resources for the DESCOM repair depots for an entire year. These programs are then partitioned into quarterly and ultimately weekly repair schedules.

involves buying sufficient stocks to absorb unpredictable workloads. The costs of this approach need to be determined. The approach would probably make sense for cheap repair parts but not for expensive ones. For some parts, purchasing quantities just in time to meet changing repair needs may be sensible. The purchase cost, on a per unit basis, would be higher than buying in bulk, but the total inventory cost may be lower depending on the item. Other approaches include using electronic data exchange to reduce administrative lead times when ordering repair parts or manufacturing repair parts when needed to meet demands from repair lines of higher assemblies. For a given set of repair parts needed to fix a set of SRUs, a mixed strategy involving more than one strategy may be appropriate. For each high-technology reparable component, the particular strategies used to ensure the availability of repair parts need to be determined.

COORDINATION OF WORKLOADS

Among MSCs and Depots

The IMs whose actions collectively affect the availability of a particular weapon system, such as the M1, are located at more than one of the MSCs. In addition, the depot repair workload for items associated with the particular weapon system are distributed among DESCOM's repair depots and contractor facilities throughout the CONUS and other parts of the world. Also, some shops, like the electro-optical shop at Sacramento Army Depot, handle workloads from several IMs whose items are used in several different weapon systems. Some of these items are tested on the same machine.[2] The workload across the shops must be sequenced to interweave items used on different weapon systems and managed by IMs at different MSCs. In addition, if some shops have workloads that constrain the availability of a particular weapon system, workloads at other shops, potentially at other depots, may have to be adjusted. To date, the DRIVE model has been tested in a single shop with test stations designed to repair high-technology components used on a single weapon system. The expansion of this capability to deal with coordination needs to take place in an evolutionary fashion.

[2]For instance, the EQUATE in the Sacramento Army Depot shop is used to test 24 different SRUs used on the M1, M2/3, and common night vision systems.

Among Echelons

To deal with the dynamic environments described in Sec. I, MMC personnel at division, corps, and theater levels need to distribute serviceable and reparable assets to keep pace with changing unit priorities and availabilities of resources. The changing circumstances will probably take place too quickly for CONUS depots to distribute assets directly to specific combat units in distant theaters. The VISION system must tie the depot to theater combat needs and yet recognize that intervening echelons will have a more current view of those needs than the depot. A nested multi-echelon decision support system is needed in which echelons closest to the battle can revise higher echelon distribution decisions and redirect assets to where they will most improve weapon system availability in units with the highest priorities.

Given this viewpoint, several system design issues must be resolved. One is to determine how far forward each echelon should attempt to look in providing direct support. The IM might use VISION to "see" asset needs at each combat unit and direct repair actions to maximize weapon system availability for those units with current information. Since unit level weapon system availability depends on the number of LRUs and SRUs available at the FSB, this approach would tie depot repair and distribution decisions most directly to weapon system availability. If visibility were aggregated in higher levels, the connection between depot support and unit level weapon system availability would be obscured because the aggregation of forecast demands and asset visibility would reflect only the needs of the aggregate unit. For instance, even with the definition of a unit proposed earlier, the IM or theater MMC could assume the FSB will take the necessary cross substitution action to maximize weapon system availability. As the aggregation scheme covers more units, this assumption would entail many more actions, such as moving assets among FSBs to maximize the number of available weapon systems within the aggregate view. Thus, the relations between depot support and weapon system availability become less direct as the level of aggregation becomes higher.

Even with a responsive depot repair time of two weeks for priority items, the combat situation is likely to have changed before the assets are repaired. As assets are repaired and placed in serviceable condition, the system could then assist the IM in making distribution decisions based upon combat unit needs at the time. Given that the combat situation will probably change while assets are in transit from the CONUS, the system design needs to consider where to send the assets. One approach would be to send assets intended to meet specific combat unit needs to an aggregated but yet still relatively forward location.

For instance, assets intended to meet the needs of a given FSB could be sent to the division MSB or corps general supply area. The corps MMC could then use a corps-level VISION system to determine which of its MSBs should get the available assets based upon the current situation. This scheme would bypass the theater level when making reallocation decisions concerning inbound CONUS shipments. Other system designs could be considered, such as giving the theater MMC a chance to intervene in the destination decisions for inbound CONUS serviceable assets. Tradeoffs between the number of decision points and the speed of delivery must be considered and evaluated. If the theater MMC is bypassed for inbound decisions on assets, it could always redistribute assets "owned" by its divisions, as could divisions and the corps.

Given that the division, corps, and theater MMCs could use VISION to determine where to distribute assets to maximize weapon system availability, each echelon needs to estimate the likely decisions that other echelons would make so it can reinforce those decisions. Having current information on weapon system availability goals and asset status at each echelon will help couple actions of each echelon to combat unit needs. For instance, if the corps and higher level systems could "see" maldistribution of assets within a division, they would need to know when to expect the division to take action to correct the imbalances. With this kind of "knowledge of expected behavior," higher echelons would anticipate actions of lower echelons.

IMPLICATIONS FOR LOGISTICS INFORMATION SYSTEMS

If VISION were developed as outlined above, several new and additional kinds of logistics data would be necessary. In turn, new means of acquiring and moving that data would also be necessary. As indicated earlier, the logistics data include asset visibility, scenarios, item indicative data (removal rates, order and ship times, etc.), interchangeable and substitutability groupings, and indenture relationships. Among these, accurate reporting of assets and their condition at each echelon (asset visibility) is one of the most important kinds of data needed to make VISION operate. Each higher echelon needs to know how many assets each FSB and MSB has and the status of those assets. Asset visibility information should be reported for all reparable items.

To obtain good estimates of removal rates needed to develop execution plans with VISION, asset usage by weapon system must be reported. Systems to obtain this information, to compute associated removal rates, and to update the Commodity Command Standard System (CCSS) should be developed to improve the accuracy of weapon system assessments and execution actions.

Good item application and indenture relationships are needed to develop proper execution plans and assessments. These files identify parent-child relationships among items, and the needed system should be able to break down the relationships of each item and indicate where it fits in the weapon system hierarchy. A good system should allow one to enter the relationship "tree" at any point with an item and work up the tree to determine the weapon that uses it. At the same time, one should be able to work down the tree to determine all items indentured to that item. In addition to building the indenture files, procedures need to be developed to keep the files current to include stock list changes, item and system modifications, etc.

Moreover, feedback systems that collect information necessary to compute process performance[3] are needed, and they must pass the data to CCSS for updating parameters such as order and ship time (OST), repair times, and the like in the National Stock Number Master Record (NSNMR). Research must include the update frequency and methods to collect and compute these parameters. Also, a method of obtaining weapon system availability goals and operating tempo-based scenarios needs to be developed. Without these goals and near-term operating tempo requirements, responsive execution plans cannot be formulated. Perhaps the Combat Service Support Control System (CSSCS)[4] could transfer this information to the VISION Execution System. This information is needed on a continuing basis. For VISION to work, methods to collect and disseminate the information to the appropriate local VISION modules are absolutely necessary. A priority effort should be established to study the problem.

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[3]Examples are repair or transportation times.

[4]The U.S. Army Logistics Center is developing an automated Combat Service Support Control System as one of five nodes composing the Army Tactical Command and Control System (ATCCS). ATCCS is planned to support battlefield commanders at and below the corps level by collecting, analyzing, and distributing combat, combat support, and CSS command and control information. CSSCS, which is also planned to be fielded to CSS units at echelons above corps, could provide commanders with command and control data gathered from standard Army management information systems. See *Revised Operational and Organizational Plan Combat Service Support Control System*, United States Army Logistics Center, Fort Lee, Virginia, November 13, 1987.

EVEN LARGER ISSUES: WORKLOAD PLANNING

Recognition of the dynamic and uncertain operational environment and the need to develop decision support systems to help logisticians make support decisions in this environment raise even larger issues. Given this environment, questions of the criteria used to assign workloads to each echelon and which of these should be organic versus contract come to the forefront. For example, should organic depot level workloads be geared to handling difficult-to-project, yet mission-essential, high-technology component workloads while large scheduled weapon system overhaul programs be contracted out?

How can facilities be designed to accept unanticipated workloads? Certainly, the Army's move to general purpose test equipment is a step in the right direction. What kinds of training programs are needed to allow personnel to move to areas that currently experience heavy demands? How should policies, procedures, and workload assignments for responsive support be developed and defended in light of increasing pressure to become more efficient?

These issues are important and require research, but they need not be resolved before a commitment is made to develop decision support systems and structures capable of dealing with uncertain environments. VISION's research and development program should build prototypes to deal with issues in an incremental fashion. Each prototype should extend the system and the production version should expand functions and incorporate changes learned in prototypes. It is conceivable that problem resolution could take five to ten years, but resolved issues need to find their way into the production system in an evolutionary fashion.

VI. RECOMMENDATIONS

As the preceding discussion has shown, the potential benefits of developing a responsive support structure that incorporates VISION Execution System capabilities appear to be significant. It appears that such a system could provide more responsive and flexible support at a lower cost than the current system. There are, however, several research issues that need to be resolved before the concept is fully implemented. Some of the important issues needing further research are identified in Sec. V. In addition, further work is needed on refining the benefits and costs of such a system.

Solutions to all need not be found before implementation takes place, but a series of evolutionary prototypes should be developed and tested to help resolve these issues while incremental development of the system proceeds, providing the benefits warrant the use of tested portions. We recommend that prototypes be developed for several other reasons: Implementing large-scale development of VISION would be risky because it differs from the current system in its objectives, data, policies, and procedures; prototypes would verify the high potential benefits of VISION; prototypes would help provide detailed design specifications that a "production" version of the system could use; and the concept needs to be validated or proven.

DEMONSTRATION AND OPERATIONAL PROTOTYPES

Prototypes should be developed in two phases to "proof the concept"—a demonstration phase and an operational phase. The prototypes should be developed for use at each echelon where the system is being considered for application. Echelons such as the theater and MSC/DESCOM have different needs, and the system must be tailored to meet them.

The demonstration phase prototypes and the operational phase prototypes have related but different objectives. Demonstration prototypes should:

- Refine the analysis of data needed to make the concept operational
- Demonstrate how the system would work using "snapshot" data
- Modify the execution model (DRIVE) to facilitate integrated and coordinated multi-echelon (theater-depot) repair and distribution workloads

- Identify policies that must be modified to allow the concept to meet its intended objectives
- Identify specific changes or additions that must be made to Army LMS to make the concept operational
- Refine cost/benefit analyses associated with developing the systems.

Given successful prototypes in the demonstration phase, operational prototypes should be developed to test them. Operational tests should:

- Verify the payoffs of the system in an operational environment
- Develop detailed design specifications for use in full-scale development
- Adapt system operations to "realities of life."

EXPANDING USES OF THE SYSTEM IN INCREMENTS

If successful demonstration and detailed cost/benefit analyses so warrant, successive increments of the execution system should then be built to expand the resources and weapon systems covered. Each increment should be considered for full-scale development and implementation. Each increment should be developed in less than one year. This prototyping and incremental development strategy reduces the risks associated with large-scale system development efforts and allows the system to expand on an evolutionary basis.

USING VISION TO INFLUENCE AN ARMY STRATEGIC DEVELOPMENT PLAN FOR LMS

As the preceding discussion has shown, VISION's concept development identifies the specific information required to implement a major set of CSSCS and WSMAP objectives, and provides a means for logisticians to meet the wartime (and peacetime) repair and distribution responsibilities outlined in FM 100-10 and FM 100-5. Moreover, it identifies specific needed information and provides insights on needed changes in existing Army LMSs. As successive VISION prototypes are developed to cover other resources and weapon systems, additional priorities for LMS enhancements and/or developments will be generated. These developments and associated analyses could be valuable inputs into an Army strategic development plan for LMSs.

Another major set of WSMAP goals is associated with developing a weapon system oriented programming and budgeting approach within

the Planning, Programming, and Budget Execution System (PPBES), not addressed here. The VISION Execution System for repair and distribution takes as givens the resources the PPBES generates. The methodology to incorporate uncertainty into programming and budgeting is not fully established. Serious questions exist regarding the modeling techniques that should be used over extended time horizons, database update frequency, controls on the variability of forecasts from period to period, effect on inventory management and MMC workloads, etc. This subject should be considered for a future Arroyo Center project. The outputs could influence an Army strategic development plan for LMS to the same extent as the VISION Execution System.